INTERMOUNTAIN POWER PROJECT

PRELIMINARY ENGINEERING AND FEASIBILITY STUDY
OCTOBER 1976

VOLUME II
PART 1

GENERATING STATION

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Department of Water and Power
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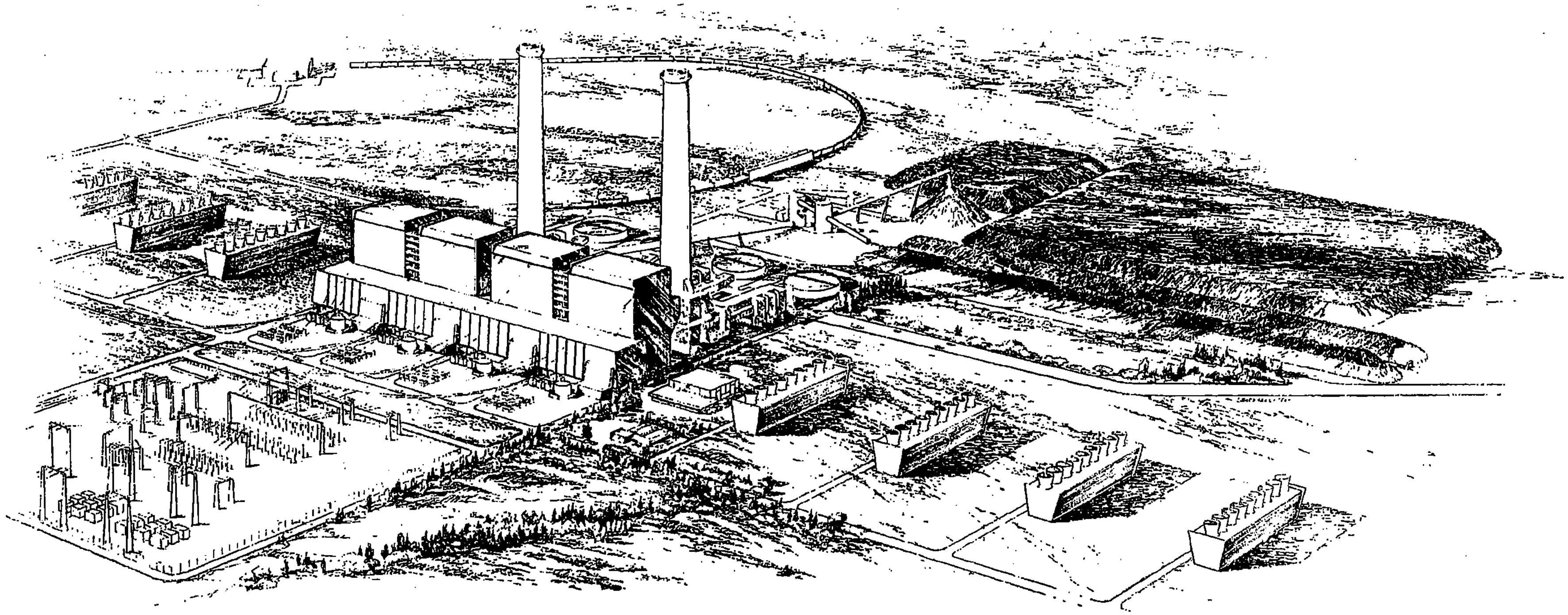

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INTRODUCTION

This volume presents the results of the preliminary design and feasibility study pertaining to the main generating station. Included are descriptions of the facilities proposed at the main plant, as well as the adjacent facilities required for water supply and solid and liquid waste disposal.

This volume is arranged generally to describe each major system. All figures are located at the end of the volume in Section 66.0 and are referred to at the appropriate point within the text. A list of references for this volume has been included in Section 64.0. The references are numbered starting with Number 1 under each section. A detailed design and construction schedule is included in Section 62.0.

The engineering studies for the generating station included first a site selection effort to select the best location for the plant. Most major systems were then selected from several conceptual alternatives on the basis of economics, reliability, and where applicable, environmental considerations. A detailed description of the many alternatives investigated and the resulting engineering analysis are not included because of their size. Instead, references are made to supporting engineering and environmental studies and reports which are on file in the Project Engineer's office, the location of which is described in Section 64.0. Where a description of alternatives and the basis for selection is required for an environmental analysis, the information will be found in Volume V.

As part of this study, "rough draft" purchase specifications were also completed for two major items of plant equipment. These are the main steam generator (boiler) and the turbine generator. It was considered desirable to complete these two specifications concurrent with this report because of the extremely long delivery time for these pieces of equipment. Due to the size and technical nature of these specifications, they were not included as part of this volume but are on file in the Project Engineer's office.

It must be emphasized that this is a preliminary design study based on estimated fuel and water analyses and estimated typical performance characteristics of turbine generators, boilers, cooling towers, and other major equipment. Only after the quality of the coal and water have been determined and after the boilers and turbine generators have been ordered will it be possible to prepare the final optimal design of the various systems described in this study. For this reason, all specific equipment and system parameters including flow rates, pressures, temperatures, and horsepowers are approximate with an accuracy sufficient for preparing Project cost estimates and construction schedules.

SECTION 1.0

LOCATION

The proposed site for the generating station described in this volume is the primary plant study site which was selected during earlier site selection studies. It is located in south central Utah, in Wayne County, and is approximately 8 miles northerly of Caineville, Utah and 24 miles westerly of Hanksville, Utah as shown in Figures A1 and A3. The plant site, as shown in Figure A5, lies within Sections 13, 14, 15, 23, and 24 of Township 27 South, Range 8 East and Sections 17, 18, 19, 20, and 30 of Township 27 South, Range 9 East, Salt Lake Meridian (SLM) and includes approximately 7-1/4 square miles (sq mi).

1.1 SITE SELECTION

The selection of the Intermountain Power Project (IPP) plant site involved an evaluation of various sites in which engineering, economic, and environmental factors were considered. The selection of sites within southern Utah focused on areas near Caineville and Escalante, Utah primarily because of water availability. Of these, the general Caineville area was preferred in both the engineering and environmental analyses. One of the five possible sites in this area was selected as the primary plant study site. More detailed descriptions of the site selection and evaluation are contained in reports by IPP (Ref 1) and IPP's environmental consultant (Ref 2).

1.2 SITE DESCRIPTION

The site is located in an arid region on the northwestern portion of the Colorado Plateau at an elevation of approximately 5000 ft. The region is of youthful geology, with deeply incised erosional features. The prominent topographic features in the general area include:

1. Caineville Reef, a northeast trending barrier to the east and south of the plant site which rises a few hundred feet above the surrounding terrain.

2. Factory Butte to the east of the plant site, which rises about 1300 ft above the surrounding terrain.

3. North and south Caineville Mesas to the south of the plant site, which both rise about 1000 ft above the surrounding terrain.

Bedrock formations in the general area are either the marine Mancos Shale, the continental Entrada Sandstone, or the variegated sands and mudstones of Morrison, Curtis, and Carmel formations. Entrada Sandstone and Carmel formations are the bedrock of the plant site and are exposed with little or no surficial deposits.

The major portion of the plant site lies on a plateau which is rimmed on the south and southwest by the 200 to 400 ft high bluffs of Wood Bench. The plateau slopes down gently toward the north and northwest and is drained by the Salt Wash which flows easterly at the northern perimeter of the site in a gorge 50 to 75 ft deep. The terrain on the plateau is generally flat adjacent to the bluffs of Wood Bench but is more rugged and incised with gullies toward the Salt Wash. Vegetation at the plant site is sparse.

SECTION 2.0

ACCESS

Three basic modes of transportation to the plant site will be used for the purpose of construction, operation, and maintenance. These include railroad, highways, and air.

2.1 RAILROAD

The south central and eastern portion of Utah is served by the Denver and Rio Grande Western Railroad (D&RG). The two nearest potential railheads to the plant site on the D&RG are at Sigurd, Utah to the northwest and Green River, Utah to the northeast. Access to the plant site from Sigurd is via Highway U-24 which contains many sharp curves and sustained adverse grades, passes through Capitol Reef National Park, and will be approximately 100 miles to the plant. Access to the plant site from Green River is via Highway I-70 and Highway U-24 and will be approximately 90 miles to the plant. This portion of Highway U-24 is relatively straight and has more gentle grades. Thus, developing a railhead at Green River as shown in Figure A3 is preferred.

Excess clearance loads are presently restricted on Highway I-70 by a bridge located approximately 1 mile west of Green River where the existing railroad passes over Highway I-70 with a clearance of 16 ft. Because of this constriction, which would prohibit the transporting of some of the larger loads, such as transformers, etc., a new off-loading site must be developed. On the west edge of Green River, there is adequate flat area adjacent to the rail line for development of a railhead and storage yard. It is estimated that approximately 10 acres will be required. Much of this land is privately owned and after approval of the Project, the necessary lease or use agreements will be negotiated. The area will require grading, temporary fencing, and possibly some crushed aggregate for base. No water or utility service is anticipated. When the railhead is no longer needed, all temporary fencing, structures, etc., will be removed and the area restored as near as possible to the original condition.

If connections could be made between the Project's proposed coal haul railroad and a mainline railroad, much of the equipment and construction materials would be delivered to the plant directly by rail. A new railroad, referred to as the Castle Valley

Railroad, has been recently proposed. This railroad will link Emery, Utah with the existing D&RG in Price-Wellington area of Utah. If it materializes and is scheduled to be completed prior to IPP's construction, negotiations will be initiated to connect the Project's coal haul railroad to the Castle Valley Railroad at Emery.

The plant will be arranged to accept direct rail deliveries; but, since direct rail delivery is not being planned at this time, it is proposed that all rail deliveries will be unloaded at the railhead in Green River and trucked to the plant using Highways I-70 and U-24.

2.2 HIGHWAYS

The nearest existing paved road to the plant site is Highway U-24. Access from Highway U-24 to the plant will be over a new permanent plant access road approximately 10 miles long as shown in Figure A4. This access road will meet Highway U-24 near Caineville and will be constructed as part of the initial site grading work.

The new access road will be designed for a safe vehicle speed of 55 mph and for the heaviest equipment loads anticipated. The roadway section will be as shown for a primary access road in Figure A23 and will include a minimum right-of-way width of 100 ft with two 11-ft-wide paved lanes and two 6-ft-wide paved shoulders. Included in this right-of-way will be the buried main water supply lines and the overhead power supply lines as shown in Figure A28. Pavement and base course thickness will be designed according to the engineering properties of the native foundation materials. Generally, a 6-in. asphalt concrete pavement and 12-in. base thickness will be provided, except on weak or expansive foundation materials such as Mancos Shale where the base course will be increased with approximately 3 ft of select material. Culverts and cross drainage will be designed for a 50-yr flood (a flood that may be expected to occur once in 50 yrs).

Delivery of heavy or excess clearance loads over the existing highways is controlled by a state permit system. Generally, loads up to 60,000 lb on an eight-tire tandem, and 75,000 lb on an eight-tire-per-axle tandem rigs are allowed. A suitable route for heavy or excess clearance loads can be developed from the proposed new railhead area at Green River. Heavy loads will be restricted by design loadings for bridges. On Highway I-70 there is one bridge which serves as an access ramp to Highway U-24. On Highway U-24 there are four bridges which cross the Muddy Creek, San Rafael, and Fremont Rivers. The latter water course is crossed twice, once northerly of Hanksville, and once westerly of Hanksville. Detours and temporary fords of these water courses, in the vicinity of the highway bridges, are possible with appropriate permits and nominal grading work. For the purpose of this study, the delivery of all heavy and excess clearance loads over this route through the development of detours and temporary fords is proposed.

Numerous other access roads to plant facilities will be required, such as the access to the ash disposal site, the dam and pumping facilities, and the well fields, and are discussed in other portions of this report. Typical sections of these roads are shown in Figure A23. The design criteria for each of these roads vary with the specific needs of these roads. The maximum grade for any paved road will be 7 percent and that for any unpaved road will be 10 percent. Minimum right-of-way for roads other than primary roads will be 80 ft. Culverts and cross drainages will be designed for a 50-yr flood for paved roads and a 10-yr flood for unpaved roads. Minimum radius of a paved road will be 275 ft and for an unpaved road will be 100 ft. All fences crossed by any road will be provided with a gate and a permanent cattleguard. All roads will be constructed so that material will not be accumulated in piles. The material will be side-cast as construction proceeds, but in such a way that a windrow will not be created. Areas where landscape features are scarred or damaged by equipment or operations will be restored as nearly as possible to their original condition. Where applicable, the damaged areas will be reseeded and stabilized with native vegetation.

2.3 AIR

The closest commercial airport is located in Grand Junction, Colorado approximately 193 miles from the plant site; the second closest, Salt Lake City, Utah is approximately 255 miles from the plant site. Because of the distance involved between the plant site and cities which are served by commercially scheduled airlines, improvement of a landing strip in the vicinity of the site to serve light utility class aircraft is proposed.

The existing airfield nearest to the plant site that could serve light aircraft is located in Hanksville (Figure A4), approximately 32 miles by road from the site. The airfield is unpaved and has no fuel services. Approximate distances by highways from the site to other airfields having paved runways are 90 miles to the one in Green River and 45 miles to Wayne Wonderland Airport near Loa and Bicknell. Both of these facilities appear too distant from the site for practical long-term usage. A paved runway is necessary because small jet aircraft will not land on unpaved strips due to possible engine damage from loose rocks, and propeller aircraft generally avoid these strips due to possible propeller damage.

Alternatives are to pave the runway at Hanksville airfield or construct a new airfield close to the plant site. The former alternative of improving the runway will require negotiations with state agencies controlling usage of the Hanksville airfield. Construction of an airstrip at the site is not practical because of limitations imposed on runway alignment to clear surrounding terrain and plant features. For the purpose of this study, it is proposed that the Hanksville airfield be improved.

SECTION 3.0

LAND

The acquisition of the lands and rights-of-way required for the Project will be as recommended in the IPP Site Acquisition Study (Ref 1). The following is a description of the land requirements for facilities in the vicinity of the generating station. Ownership of the lands described is based upon Bureau of Land Management (BLM) "State of Utah Land Ownership and Public Management Maps" as last revised. Land requirements for transmission lines are discussed in Volume III and for the coal haul railroad and community development, in Volume IV.

3.1 PLANT SITE

The location of the plant site is described in Section 1.0 and shown in Figures A3 and A5.

The plant site will require 4640 acres or 7-1/4 sections of land for the power plant complex, including the evaporation ponds, coal storage area, converter station, and the preferred solid waste disposal area. All 4640 acres are on federal land presently under the management of BLM. IPP plans to acquire the land for the plant site in "fee title" through the State Selection Program, or by whatever method is most advantageous at the time. In the State Selection Program, the "In Lieu Lands" which are lands that Utah has never owned, but which the Federal Government owes Utah, are exchanged for the pertinent BLM lands. IPP will acquire the land for the plant site in fee from the state. Fee title to the land will give IPP substantial control over the property within the site boundaries.

3.2 ACCESS ROAD TO PLANT SITE

Approximately 10 miles of permanent access road, as shown in Figure A4, will be required from Highway U-24 to the plant, about 7 miles on BLM administered land, about 1 mile on Utah State land, and 2 miles within the proposed site boundary. To accommodate the proposed 100-ft wide right-of-way for the road, approximately 85 acres of BLM administered land and 12 acres of state land will be required. Formal applications will be made with BLM and the Utah Division of State Lands (UDSL) as required for a Grant of Right-of-Way for a 100-ft wide permanent easement.

3.3 RED DESERT RESERVOIR SITE

The Red Desert reservoir site is located approximately 2 miles west of Caineville, Utah as shown in Figures A4, A10, and A11. An area of 3840 acres or 6 sections of land will be required for the reservoir site, which includes the on-site permanent access roads and adjacent well fields. About 3360 acres of the required 3840 acres are on BLM administered land and 480 acres are on state lands. In addition, about 0.6 mile of off-site permanent access road on BLM administered land will be required from Highway U-24 to the reservoir site. A 100-ft wide easement involving about 7 acres of land will be required for the access road. Formal applications will be made with BLM and UDSL as required for a Grant of Right-of-Way for the reservoir site and the easement for the off-site access road.

The water supply pipeline and the power lines from the reservoir pumping plant to the plant site will be adjacent to the permanent access roads and will occupy the same right-of-way as the roads, therefore, an additional right-of-way will not be required.

3.4 DIVERSION WORKS - FREMONT RIVER

The diversion works on the Fremont River, which will provide water for the Red Desert Reservoir, will be located about 3 miles southwest of Caineville, as shown in Figure A4. A land area of 100 acres will be required for the diversion works and the pumping plant as shown in Figure A13. About 0.3 mile of access road will be required between Highway U-24 and the diversion works. The water supply line from the diversion works pumping plant to the Red Desert Reservoir and the power lines to the pumping plant will be adjacent to the permanent access roads and the shoulder of Highway U-24, hence an additional right-of-way will not be required. An encroachment permit will be obtained for the facilities adjacent to Highway U-24.

Formal applications will be made with UDSL for a Grant of Right-of-Way for lands under their jurisdiction. Private lands will be acquired in fee.

3.5 FREMONT RESERVOIR ALTERNATIVE

The Fremont Reservoir is an on-stream reservoir proposed as an alternative to the Red Desert Reservoir and Fremont River

Diversion Works as discussed in Section 6.0. The site for the reservoir is located approximately 3-1/2 miles southwesterly of Caineville, Utah as shown in Figure A12. An area of 3840 acres or six sections of land will be required for the reservoir site including the on-site permanent access roads and adjacent well fields. 2960 acres of the required 3840 acres are BLM administered land, 480 acres are state land, and 400 acres are private land. Approximately 4.5 miles of Highway U-24 will be relocated with about 3 miles within the reservoir site area. A 100-ft wide easement involving about 37 acres for Highway U-24 will be included in the total of 3840 acres. In addition, about 1.1 miles of off-site permanent access road on BLM administered land will be required from Highway U-24 to the reservoir site. A 100-ft wide easement involving about 13 acres will be required for the off-site access road. Formal applications will be made with BLM and UDSL as required for a Grant of Right-of-Way for the reservoir site and the easement for the off-site access road. Private land will be purchased in fee.

3.6 GROUNDWATER FILINGS AND WELL FIELDS

The proposed well fields, as shown in Figure A20, will be located to the northwest, west, and south of the plant site in Sevier, Emery, Wayne, and Garfield Counties. Groundwater filings have been made with the Utah State Engineer in 90 sections of land which are not included in the plant site or the Red Desert reservoir site. Land ownership of the proposed off-site well field areas are as follows:

TABLE 3-1

LAND OWNERSHIP OF WELL FIELDS

	Acres	Sections
Bureau of Land Management	45,120	70.5
N. Forest	2,880	4.5
Private	3,200	5.0
State	6,400	10.0
TOTAL	57,600	90.0

Land requirements for the access roads to the wells and water conveyance facilities will be determined after the actual well locations are established. Formal applications will be made with

BLM, UDSL, and National Forest Service for a Grant of Right-of-Way. Private lands will be acquired in fee.

SECTION 4.0

EMPLOYMENT

The construction and operation of IPP will create a large labor market. Personnel will be required to construct and operate the power plant complex, coal-mines, coal transportation system, transmission lines, and the lime supply system.

In this section, the projected labor force required to construct and operate the power plant complex is defined as well as any problems associated with obtaining the necessary labor force. Volume IV describes the labor force that will be required for all other portions of the Project. Volume IV also discusses the community needs associated with the entire Project employment along with describing where the personnel are anticipated to live and the efforts IPP will make to minimize the impacts of these workers.

The estimated labor force required for the construction and operation of the power plant complex is shown in Figure A25. Included is the site grading, access roads, dams, pumping plants, well fields, water conveyance system, waste disposal areas, generating station, and the on-site coal handling facilities. It is anticipated that construction will be during two shifts per day, five days per week. It is anticipated that two-thirds to three-fourths of the construction labor forces will be on the day shift and the remainder on an evening or graveyard shift. Operation and maintenance will be performed around the clock with approximately 410 of the 550 personnel on duty during any given day.

IPP has met with several local agencies to discuss the labor needs in an effort to employ as many of the local labor force as possible. The Utah State Employment Security Office has pledged its support in training necessary recruits through local schools to aid in providing the necessary personnel. Additional studies are planned with other organizations including the Utah State Manpower Planning Agency in an effort to hire as many local people as possible. That portion of the labor pool that is not from Utah will be made up from labor pools primarily from the western states, while some highly specialized tradesmen will be obtained from throughout the United States.

Non-manual labor needs for the plant construction will be significantly less than the manual labor needs. The non-manual force will be made up of professional, technical, supervisory, administrative, and clerical skills. A high portion, possibly 60 to 70 percent, of these people will be imported by a major engineer-construction firm, whose personnel will form the core of the power plant engineering and construction expertise. The remainder of the non-manual workers will be sought locally.

IPP recognizes that it must continue to work with the local, state, and national labor groups and employment agencies to assure that a sufficient labor force is available for construction. Any failure in providing the necessary labor forces will extend the construction schedule and will be costly to the Project.

SECTION 5.0

COAL SUPPLY

During the feasibility study, the extent, conditions, and ownership of coal lands near the study site were investigated as to the possibility of supplying the estimated coal requirements for IPP as shown in Table 5-1. The results of this investigation indicate that the Emery, Wasatch Plateau, and Kaiparowits Plateau fields (Figure A2) each contain uncommitted or unleased coal reserves containing quantities of coal many times that needed to supply the plant. These areas generally require underground mining techniques due to the depths of the coal seams. The Henry Mountains area also has the potential to supply up to one-third of the Project's need from seams which would be recovered utilizing surface mining techniques.

The areas which are most likely to be developed to supply the coal necessary to fuel the plant are the southern portions of the Emery and Wasatch Plateau coal fields. A coal haul railroad will be constructed to transport the coal from the mining areas to the plant site by unit trains. Sections 1.0 and 2.0 in Volume IV, Employment Needs and Coal Supply System, include detailed information on the coal supply and transportation systems.

TABLE 5-1

ESTIMATED COAL REQUIREMENTS*
(In million tons)

YEAR	Unit 1	Unit 2	Unit 3	Unit 4	Total
1	2.191	0	0	0	2.191
2	2.336	2.191	0	0	4.527
3	2.336	2.336	2.191	0	6.863
4	2.336	2.336	2.336	2.191	9.199
5	2.482	2.336	2.336	2.336	9.490
6	2.482	2.482	2.336	2.336	9.636
7	2.482	2.482	2.482	2.336	9.782
8	2.482	2.482	2.482	2.482	9.928
9	2.482	2.482	2.482	2.482	9.928
10	2.482	2.482	2.482	2.482	9.928
11	2.347	2.482	2.482	2.482	9.793
12	2.347	2.347	2.482	2.482	9.658
13	2.347	2.347	2.347	2.482	9.523
14	2.347	2.347	2.347	2.347	9.388
15	2.347	2.347	2.347	2.347	9.388
16	2.347	2.347	2.347	2.347	9.388
17	2.347	2.347	2.347	2.347	9.388
18	2.204	2.347	2.347	2.347	9.245
19	2.204	2.204	2.347	2.347	9.102
20	2.204	2.204	2.204	2.347	8.959
21	2.204	2.204	2.204	2.204	8.816
22	2.204	2.204	2.204	2.204	8.816
23	2.204	2.204	2.204	2.204	8.816
24	2.068	2.204	2.204	2.204	8.680
25	2.068	2.068	2.204	2.204	8.544
26	2.068	2.068	2.068	2.204	8.408
27	2.068	2.068	2.068	2.068	8.272
28	2.068	2.068	2.068	2.068	8.272
29	1.922	2.068	2.068	2.068	8.126
30	1.922	1.922	2.068	2.068	7.980
31	1.922	1.922	1.922	2.068	7.834
32	1.922	1.922	1.922	1.922	7.688
33	1.791	1.922	1.922	1.922	7.557
34	1.791	1.791	1.922	1.922	7.426
35	1.791	1.791	1.791	1.922	7.295
36	0	1.791	1.791	1.791	5.373
37	0	0	1.791	1.791	3.582
38	0	0	0	1.791	1.791

TOTAL FOR PROJECT LIFE......308.580
AVERAGE ANNUAL RATE (4 UNITS)...... 8.121

*Based on average lifetime heating value of 11,500 Btu/lb and a 75% load factor.

SECTION 6.0

WATER SUPPLY

Water for the Project will be developed from two sources to provide an adequate and reliable supply. Surface water will come from the Fremont River and groundwater will be developed from an underground aquifer in the Navajo Sandstone. For reasons associated with water rights, water quality, and plant reliability, surface and groundwaters will not be combined until after they are delivered to the plant site.

6.1 PROJECT WATER BUDGET

The total water supply will be based on the requirement to have 50,000 acre-ft/yr of water available to IPP. This requirement represents the maximum Project needs including cooling, industrial, domestic and construction water requirements. The 50,000 acre-ft/yr will be made up of approximately 30,000 acre-ft from surface water and 20,000 acre-ft from groundwater.

A diagram showing the water budgeted for IPP use is shown in Figure A9. The budget indicates the estimated losses from evaporation and seepage and gains from precipitation or tributary watershed for the surface water reservoir. Other losses in the water supply systems, such as pipeline leakage, are considered negligible. In-plant water usage is represented by those processes which ultimately consume the water. Other processes which use water but result in water being reused within the plant are not indicated.

The annual water consumption shown is for an average weather year, with the plant loaded at 100 percent capacity in the months of June, July, and August, and 80 percent in the remaining months. This results in an average yearly plant loading of 85 percent, the highest estimated plant load factor assumed for the purpose of this study.

The water budget figures also represent the plant water balance with assumed qualities and mix of underground and surface waters. The water balance for the plant, including all water processes and reuse of water, is described in Section 31.0, Plant Water Balance.

The quantity indicated for reserve provides for possible increased water demand due to variation in water chemistry or water loss. Water chemistry may affect the reuse of water for cooling or flue gas desulfurization.

6.2 SURFACE WATER SYSTEM

The surface water system will consist of all facilities necessary to:

1. Divert water from the Fremont River.
2. Pump and convey this water to a storage reservoir.
3. Store this water in the reservoir.
4. Pump and convey this water to the power plant.

The system will supply surface water to the plant's industrial water system at motor controlled butterfly Valve V-RWH19 (Figure B34).

6.2.1 SOURCE

The surface water source will be the Fremont River. The Fremont River flows easterly, passing approximately 8 miles southerly of the plant site. The river at its confluence with Muddy Creek near Hanksville becomes the Dirty Devil River which flows southeasterly and joins the Colorado River.

A water right granted by the Utah State Engineer to the Utah State Board of Water Resources allows diversion and storage of up to 50,000 acre-ft of water annually from the Fremont River provided that prior rights of downstream users are also satisfied.

The people in Wayne County approved formation of the Wayne County Water Conservancy District (WCWCD) in the spring of 1975 to assure proper development of water usage from the Fremont River. The nine appointed members of the WCWCD Board of Directors represent each irrigation district within the county and one represents the county "at large". The WCWCD requested and received a transfer of the water right held by the Utah State Board of Water Resources to the WCWCD. The Board of Water Resources indicated that the transfer of its water right would allow for development and beneficial use of the water while having the water rights vested in the people of the county.

ICPA and WCWCD have entered into an agreement to develop a multi-purpose water storage project which will utilize this water right. The water storage project will make water available to downstream users in accordance with their water rights, as well as to WCWCD and the Project.

Independent hydrologic studies have been made by the State of Utah, Division of Water Resources (Ref 1) and IPP (Ref 2), which conclude that 30,000 acre-ft annually can be diverted for use by IPP with the development of the appropriate water storage facilities.

6.2.2 SURFACE WATER QUALITY

Analyses of water samples taken from the Fremont River indicate that this water is relatively consistent in chemical constituents through a wide range of discharge rates. The major variation in the water quality is in suspended and settleable solids. When the river discharge is created by thunderstorm runoff and when the base flow rate is low, primarily in the months of July, August, and September, the water contains high amounts of suspended sediment. Representative water sample analyses for a low and a high suspended sediment discharge in the river are shown in Table 6-1.

TABLE 6-1

QUALITY ANALYSIS OF
WATER FROM THE FREMONT RIVER
NEAR CAINEVILLE, UTAH
(Chemical Results in Parts Per Million)

	High Sediment Sample	Low Sediment Sample
Date	10/30/74	12/11/74
Settleable Solids (mg/l)	25	0.3
Specific Electrical Conductance (Kx million)	896	640
pH (Laboratory)	8.10	7.67
Calcium (Ca)	112	77
Magnesium (Mg)	33	23
Total Hardness as $CaCO_3$	416	288
Sodium (Na)	30	22
Potassium (K)	6.5	3.6
Alkalinity as $CaCO_3$ (Total-laboratory)	169	150
Sulfate (SO_4)	284	154
Chloride (Cl)	22	17
Silica (SiO_2)	26	28
Iron (Fe)	0.80	0.20
Boron (B)	0.19	0.15
Fluoride (F)	0.26	0.20
Nitrate (NO_3)	1.7	2.8
Total Kjeldahl Nitrogen (N)	--	0.32
Phosphate (PO_4)	0.53	--
Total Dissolved Solids	574(est)	462

The quality of the surface water delivered at the plant will be essentially the same as at the Fremont River with two exceptions. First, the suspended sediments are assumed to be reduced between 85 to 95 percent by retention in the storage reservoir. The proposed locations for the intake and outlet facilities in the reservoir will be separated in distance to allow a maximum retention time in the reservoir. The outlet from the reservoir will have a single, fixed level, intake which could result in greater sediment transfer through the reservoir should reservoir stratification occur. In this event, sediment will be reduced either by filtration at the power plant or by destratification by induced mixing at the reservoir.

The second difference is that the dissolved solids content of the surface water delivered to the power plant will be higher than at the river due to evaporation and solution of soluble salts at the reservoir. Reservoir evaporation is expected to be approximately 12 percent of the total water delivery from the reservoir. Thus, ultimately the dissolved solids concentration in the reservoir should increase by the same percentage. The solution of soluble salts from within the reservoir may be noticeable during the initial reservoir usage and should become negligible due to the large volumes of water transferred through the reservoir.

6.2.3 RESERVOIR STUDIES

Two alternative developments for the storage of surface water are proposed. The first involves construction of an off-stream reservoir in the Red Desert area northwesterly of Caineville, referred to as the Red Desert Reservoir. This development will include a low diversion dam on the Fremont River, the Red Desert Reservoir and Dam, a pumping plant and pipeline to supply the Red Desert Reservoir, a second pumping plant at the base of the Red Desert Dam, and a pipeline to supply the plant.

The second alternative involves construction of a storage reservoir on the Fremont River, approximately 3-1/2 miles southwesterly of Caineville, referred to as the Fremont Reservoir. This development will include an earth-fill dam and reservoir on the Fremont River, a single pumping plant at the base of the dam, and a pipeline to supply the plant. A map showing the general location for these two alternative developments is presented in Figure A10.

The Fremont Reservoir alternative appears economically more attractive on the basis of lower pumping energy requirements.

However, due to inconclusive sedimentation data for the Fremont River, the Red Desert Reservoir is currently considered the more favorable reservoir site. For this reason, intensive geotechnical and engineering studies at the feasibility level have been conducted for the Red Desert Reservoir; whereas, minimal feasibility-level studies have been conducted for the Fremont Reservoir alternative.

Selection between these two proposed water storage projects will be subject to further studies on: 1) geotechnical feasibility, 2) reservoir sedimentation, 3) environmental impact, and 4) land use and management. IPP is planning to conduct these studies prior to the start of detailed design of the Project.

6.2.4 FREMONT RIVER DIVERSION WORKS AND PUMPING PLANT

The Fremont River Diversion Works and Pumping Plant will be located on the Fremont River approximately 3 miles southwesterly of Caineville.

The Fremont River Diversion Works will consist of a low diversion dam, gated spillway, and appropriate water control gates and intakes. The plan and details for a preliminary design are shown in Figures A13 and A14, respectively.

The diversion dam will be an earth embankment spanning approximately 460 ft across the river gorge. The dam will contain a gated spillway structure with concrete wing walls and sill. The dam and gated spillway will be designed to control the flow of the river and be able to pass a flood having a probability of occurance of once in 100 yrs. In the event of a greater magnitude flood, the low earth embankment section will be overtopped. Repairs to the embankment, should the event occur, are considered nominal compared to the cost of greater spillway capacity. Preliminary design was based on estimated 100-yr flood flow of 22,000 cfs.

The gated spillway will consist of multiple tainter-type gates which, in addition to allowing release of flood flows, will back up the river and form a regulatory pool of approximately 200 acre-ft for the pumping plant. A short intake conduit with a control gate and trash rack will convey water from the regulatory pool to the adjacent pumping plant.

The pumping plant will be enclosed within a pump house constructed on an earth fill pad at the northerly abutment of the diversion dam. The elevation of the pad will be approximately 3 ft higher than the rest of the earth diversion dam to assure protection of the pumping plant from floods greater than the 100-yr flood. The pump house will contain pumps, motors, associated piping, valves and controls, spare parts, service area, and overhead crane. There will be five vertical lineshaft pumps having a capacity to pump approximately 30 cfs each or 150 cfs total.

The pump house will be served by a paved secondary access road, approximately 1/2 mile long, leading from Highway U-24. A typical cross section is shown in Figure A23. Electrical power supply and supervisory control is described in Section 6.4. An electrical substation will be located on a fill area downstream from the diversion dam and serve as a terminus for overhead transmission lines from the plant.

The pumping plant will discharge water into a 48-in. diameter pipeline approximately 3.3 miles long, which will convey the river water to the Red Desert Reservoir. The maximum static lift will be 260 ft and the dynamic pumping lift at maximum discharge of 150 cfs will be approximately 395 ft. The operation of the proposed Fremont River pumping station will be curtailed at those times when the sediment load carried by the river becomes very high and it is not desired to pump this high sediment-laden water to the Red Desert Reservoir. It is estimated that the maximum tolerable sediment load pumped will be 5000 ppm. Statistically this situation occurs only during May through September when there are intense local thunderstorms. At this time the tainter gates will be opened and the sediment-laden storm waters allowed to pass. At the same time the waters will flush out accumulated sediment from the Fremont River forebay. The tainter gates will also be opened to release excess river flow whenever the flow exceeds 150 cfs.

6.2.5 RED DESERT RESERVOIR

The Red Desert Reservoir will be formed by a dam in an unnamed tributary to the Caineville Wash as shown in Figure A11.

6.2.5.1 WATER BODY

The reservoir will provide a maximum storage volume of 50,000 acre-ft of which 5000 acre-ft is allowed for sedimentation. The remaining 45,000 acre-ft is considered the total active storage available to the water storage project.

The reservoir will be managed to keep the reservoir as full as possible. Seasonal drawdown will commence approximately in April of each year, when the demands of the plant and irrigation water usage from the reservoir exceeds inflow diverted from the Fremont River. Storage will be increased commencing approximately in October of each year when water demands decrease below the inflow. For average water runoff in the Fremont River, the estimated maximum seasonal drawdown will be approximately 14,000 acre-ft. The 45,000 acre-ft of total active storage will ensure against a succession of yrs of below normal runoff.

A simulated 10-yr reservoir operations study, using historical flow data for the period 1966-1975 and assumed water deliveries of 36,100 acre-ft/yr (25,000 to IPP, 1100 to new municipal use, and 10,000 to agricultural or other uses) in addition to prior existing rights, indicates that the reservoir will be drawn down below 25,000 acre-ft in storage five times and to a maximum drawdown of 17,000 acre-ft in storage once, and that spilling over the diversion works due to the reservoir being completely full will occur only once in a typical 10-yr period.

The reservoir will have a surface area of approximately 1000 acres at maximum storage. The relationships of surface area and storage volume with elevation are shown in Figure A19.

6.2.5.2 RED DESERT DAM

The Red Desert Dam will be a compacted earth embankment consisting of approximately 2.6 million cu yd of material. It will have a maximum height of 172 ft above the streambed and an approximate crest length of 1000 ft. A general plan for the dam and related facilities is shown in Figure A15. The typical section for a preliminary design of the dam is shown in Figure A16.

A preliminary geological and foundation investigation of the proposed dam site was made in August 1975 (Ref 3). It concluded that the site is suitable for an earth embankment dam. The soil parameters derived from the study were used in the preliminary design of the embankment but additional soils investigation work will be required for the final design.

The dam site is underlain at the stream level by up to 25 ft of alluvium which lie on top of the Summerville Formation. The Summerville Formation will be the foundation bedrock for the embankment, embankment and abutment keys, and the spillway channel.

The abutments will require the stripping of approximately 5 ft of native material to prepare the surface for fill. In the region of the impervious core, stripping of approximately 15 ft of native material will be required to reach sound unweathered bedrock. Since the Summerville Formation contains some water-soluble salt in the form of gypsum deposits, additional treatment such as lining or grouting is anticipated in the region of the impervious core.

The foundation on the valley floor will require stripping of about 10 ft of native material, except in the area of the impervious core where all native material will be removed to the depth of bedrock. The upper 15 ft of the Summerville Formation may be weathered with fracture zones and may require a cutoff core-trench to reduce excessive seepage or the possibility of piping. Based on in-place tests, there should be no significant leakage through the remainder of the foundation material. Therefore, for the purpose of this study, only minimum grouting in addition to a core trench are anticipated.

The two types of dams recommended for the site are homogeneous and zoned embankment dams. The final selection of the dam type will be made after further soils and economic analyses. However, the following conditions led to the selection of a zoned rather than a homogeneous dam for the purpose of this study: 1) possible economic advantage of steeper slopes and a reduction in total volume of embankment material, 2) better control of seepage, 3) possibly the need to keep a greater portion of the downstream embankment unsaturated for seismic stability, and 4) assurance that the cost estimate is adequate for either a homogeneous or zone dam, as zoned dams traditionally cost more to construct. The proposed borrow sites for the construction of the dam are shown in Figure A17.

The impervious core, Zone 1, will consist of approximately 620,000 cu yd of silty clay material from Mancos Shale deposits located near the Caineville Reef, approximately 2 miles from the dam and designated Zone 1 in Figures A16 and A17. This material is practically impermeable, with permeability assumed to be less than 0.00000001 cmps.

The upstream and downstream shell material, Zone 2, will consist of approximately 1,680,000 cu yd of either Entrada Sandstone, available from the reservoir area; upper Curtis Formation and Summerville Formation material, available from the abutments; spillway cut; or the tops of the hills adjacent to the dam designated Zone 2 in Figures A16 and A17. The Entrada Sandstone will be used as the bulk of the shell material and the upper Curtis and Summerville material will be used only where more economical.

Approximately 260,000 cu yd of filter and drain material (Zone 3) will be processed from the Salt Wash Sandstone member of the Morrison Formation which will be obtained from the cap rock just east of the dam site designated Zone 3 in Figures A16 and A17. Drain material will be required on the downstream side of the impervious core and filter material on the outside surfaces of the shell embankment for bedding of slope protection.

The downstream surface of the dam will be protected by approximately 40,000 cu yd of cobbles and riprap obtained from the Salt Wash Sandstone which will be a by-product of the processing of the Zone 3 material. The upstream surface of the dam will be protected against the drawdown cycle and wave action by lining the surface with soil cement, which will utilize the Entrada Sandstone as the base material.

Any concrete required at the dam will be transported from a batch plant located at the power plant as shown in Figure A24.

It is estimated that the average borrow depths will be as follows: Zone 1, 15 ft; Zone 2, 30 ft; and Zone 3, 20 ft. With allowances for estimated waste, bulking, etc., approximately 30 acres of borrow area will be required for Zone 1, 45 acres for Zone 2, and 15 acres for Zone 3.

A temporary screening plant will be located in the reservoir area for processing the Salt Wash Sandstone into filter, drain, cobbles, and riprap materials. Stockpiles will be within the reservoir area. Temporary unpaved access roads to the borrow sites will be constructed to the borrow sites as shown in Figure A17. These roads will be approximately 36 ft wide.

Construction water will be obtained from the Fremont River or well fields that are already developed and will be trucked or piped to the dam site via a temporary construction pipeline that will be removed at the completion of the dam construction. Drinking water will be provided by truck from the nearest source of drinking water. Temporary electrical power will either be supplied from the plant site over the permanent power lines that will serve the pumping plant or by portable motor generators.

It is anticipated that all construction will be done with conventional earth moving equipment used on large scale off-road projects. As much of the construction activities and laydown area as possible will be within the boundaries of the reservoir.

As construction work is completed, all temporary structures, fencing, utilities, and refuse will be removed. The cleared areas will be blended into the normal landscape of the vicinity. Borrow sites will be smoothed and graded to blend with the adjacent landscape. All temporary construction access roads, developed but not designed as permanent patrol or access roads, will be closed and similarly rehabilitated. Where applicable, cleared or graded areas will be stabilized and seeded to restore them to their original condition.

In order to pass storm flows during the construction of the dam, use of the outlet works in a partially completed configuration will be employed. A cofferdam will be designed to provide sufficient storage and head above the outlet to provide protection up to a 50-yr flood. This cofferdam will be designed to be incorporated into the upstream shell of the embankment.

6.2.5.3 SPILLWAY SYSTEM

The Red Desert Dam will be protected against overtopping by a spillway system, which includes the outlet works as a service spillway and an ungated overflow weir as an emergency spillway.

The drainage area tributary to the reservoir is approximately 10 sq mi and runoff from a 100-yr flood can be contained within an additional 2 ft of storage above the maximum storage elevation. Therefore, the primary protection against overtopping due to floods will be an additional 2 ft of freeboard on the dam and use of the outlet works as a service spillway to release excess water storage.

The emergency spillway, which will not be utilized until the occurance of a flood greater than a 100-yr flood, will provide protection against overtopping of the dam up to the probable maximum flood. The probable maximum flood, defined as a flood for a given watershed with virtually no chance of being exceeded, is an appropriate design criteria for a major dam upstream from an inhabited area.

The emergency spillway will be a concrete, ungated overflow weir and channel in an open excavation through the ridge near the southerly dam abutment as shown in Figure A15.

The preliminary design for the spillway indicates that an overflow weir 50 ft long can provide adequate discharge capability with a maximum flood surcharge of 6 ft above the crest of the weir. Because of the remote possibility of discharge over this structure, the concrete channel will be extended downstream from the overflow weir only as far as necessary to protect the weir.

6.2.5.4 OUTLET WORKS

The outlet works for the Red Desert Dam will primarily serve the purpose of releasing water to the water users. Additional functions of the outlet works will be reservoir releases for flood protection or other emergencies, and stream diversion during construction. The details of a preliminary design for the outlet works are shown in Figure A18.

The reservoir blowoff will have a maximum discharge capacity of 1400 cfs and will provide for lowering of the upper one-half of the reservoir storage within 10 days. Energy dissipation will be accomplished during blowoff by use of valves such as hollow jet valves in combination with a concrete stilling basin.

The outlet works will convey water through the dam embankment in a circular reinforced concrete conduit. At the upstream end of the conduit, there will be a single level, fixed intake structure. The intake structure will have fixed trash racks.

Fish screens will also be provided to limit fish intake or injury. These screens will have net opening area of not less than 200 sq ft, thereby producing an intake velocity of not more than 0.5 fps during normal range of discharge.

The maximum discharge during normal water delivery will be 100 cfs. The lip of the intake structure will be set at an elevation so that 100 cfs delivery is assured throughout the range of the reservoir's 45,000 acre-ft of active storage.

The stream diversion works, required for dam construction, will include a 5 x 7-ft outlet gate at the base of the intake structure and a stilling basin at the downstream end. After construction of the dam, the intake portion will be plugged and the stilling basin will be incorporated into the permanent blowoff system for the outlet works.

6.2.5.5 RESERVOIR PUMPING PLANT

A pumping plant will be required to lift the water from the Red Desert Reservoir to the plant site. The pumping plant will be enclosed in a pump house located at the toe of Red Desert Dam as shown in Figure A15. The facility will be primarily a pressure boosting facility, taking water and discharging under pressure into the water conveyance pipeline.

The pump house will contain pump motors, associated piping, valves and controls, spare parts, service area, and overhead crane. Preliminary layout for the pump house is shown in Figure A18. There will be four horizontal shaft centrifugal pumps manifolded to a discharge line to serve the power plant supply pipeline. The four pumps will have a capacity to pump approximately 25 cfs each against a maximum dynamic head of 520 ft. Three of these pumps will normally be operational and will have sufficient capacity to supply the maximum total water demand at the power plant of approximately 70 cfs. The fourth pump will serve as standby to provide for maintenance and reliability of the supply. The pumping plant will discharge water into a single pipeline approximately 10.6 miles long which will convey the water to the power plant. The major portion of this pipeline will be located in the access road right-of-way as shown in Figure A28. The maximum static lift will be approximately 400 ft.

The pumping plant will be served by a paved secondary access road as shown in Figure A23, extending westerly approximately 1 mile from the plant access road to the generating station. Electrical power supply and supervisory control for remote operation from the generating station will be provided as described in Section 6.4. An electrical substation will be located adjacent to the pump house and serve as the terminus for overhead transmission lines from the power plant.

6.2.5.6 RECREATION

The general plan for the reservoir, Figure A11, delineates areas which are suitable for development for recreational uses. IPP believes that use of these recreational areas is compatible with the use of the reservoir by IPP and WCWCD. Also, IPP believes that recreational development at the reservoir would complement existing and planned recreational facilities in southern Utah. However, this determination should be made by the appropriate federal, state, and local governmental agencies.

For these reasons IPP will make the potential recreational areas at the reservoir available to state and/or local agencies for development and operation, to the extent that such development and operations are compatible with other uses of the reservoir.

6.2.6 WATER CONVEYANCE

The surface water system will include the construction of pipelines to convey water to the Red Desert Reservoir and the power plant as shown in Figure A31. The pipeline from the Fremont River pumping plant to the reservoir will be located adjacent to Project access roads and Highway U-24. The pipeline will be approximately 3.3 miles long and have capacity to convey a maximum discharge of 150 cfs from the river to the reservoir. The pipeline from the reservoir to the power plant will be located adjacent to Project access roads, as shown in Figure A28, and will be approximately 10.6 miles long. This pipeline will have capacity to supply the maximum total plant water demand of approximately 70 cfs and will extend to a motor controlled butterfly valve of the plant's industrial water system.

All pipelines will be constructed in cut trenches with 4 ft of earth cover for protection from freezing and accidental damage. Drain lines will be provided at each end and at intermediate sag points to facilitate draining for maintenance or inspection. Air vents and vacuum breaking valves will be provided at local summits in the pipeline.

Water for prior right irrigators and WCWCD will be made available either at the Fremont River Diversion Dam or from the Red Desert Dam. Stock watering requirements during the non-irrigation season may require the construction of small holding ponds or tanks to limit the amount of water releases required to meet these minimal requirements.

6.2.7 SURFACE WATER SYSTEM ALTERNATIVE

An alternative to the Red Desert Reservoir is the Fremont Reservoir. The primary concern of IPP with the Fremont Reservoir site is that siltation of the reservoir does not significantly deplete the storage volume during the operational life of the Project. To determine this, a comprehensive sediment transport study is needed and has now been initiated. It is expected that this study will take at least 12 months to gather data and several more months to evaluate the information gathered. If the Fremont Reservoir alternative is selected, there will be no need for the Fremont River diversion works and pumping plant described in Section 6.2.4 or the Red Desert reservoir, dam, or pumping plant described in Section 6.2.5. These facilities will be replaced by a dam, reservoir, and pumping plant located on the Fremont Reservoir approximately 3-1/2 miles southwesterly of Caineville as shown in Figure A12. The reservoir will have a comparable storage volume to the Red Desert Reservoir.

6.2.7.1 WATER BODY

The reservoir will provide a maximum storage volume of 50,000 acre-ft of which 5000 acre-ft is allowed for sedimentation. The reservoir will be managed in the same manner as that proposed for the Red Desert Reservoir described in Section 6.2.5.1. The water surface area for the Fremont Reservoir at a storage volume of 50,000 acre-ft is 1300 acres. The relationships of surface area and storage volume with elevations of the reservoir are shown in Figure A27.

6.2.7.2 FREMONT DAM

The Fremont Dam will be either a compacted earth embankment or rock-filled dam consisting of approximately 2.6 million cu yd of materials. It will have a maximum height of 159 ft above the streambed and an approximate crest length of 1200 ft. A general plan for the dam and related facilities is shown in Figure A12. The typical section for a preliminary design of the dam is shown in Figure A26.

Preliminary geological and foundation investigation of the proposed dam site was made by the City of Los Angeles, Department of Water and Power (DWP) in November 1975. It was concluded from this review that, pending detailed geologic review, the site is suitable for an embankment type dam.

The dam site is underlain at the stream level by as much as 40 ft of sandy-silt alluvium which lies on top of the bedrock. The bedrock may be weathered to a depth of 10 ft or more beneath the alluvium. The Summerville Formation and the Salt Wash Sandstone will be the foundation bedrock for the embankment, and the embankment and abutment keys.

The Brushy Basin member of the Morrison Formation will be the foundation material for the spillway channel.

It has been assumed that the abutments and canyon bottom will require approximately the same treatment as that specified for the Red Desert Dam site described in Section 6.2.5.2.

As for the Red Desert site, the final selection of the dam type will be made after further soils and economic analyses. Again, a zoned earth-filled dam was selected for the purpose of this study. The proposed borrow sites are shown in Figure A30.

The impervious core, Zone 1, will consist of approximately 630,000 cu yd of silty clay material from Mancos Shale deposits located in the proposed reservoir area and designated Zone 1 in Figures A26 and A30.

The upstream and downstream shell material, Zone 2, will consist of approximately 1,600,000 cu yd of either Summerville Formation and upper Curtis Formation, available north of the dam site approximately 2 miles and designated Zone 2 and 3 in Figures A26 and A30.

Filter, drain, cobbles, and riprap materials, Zone 3, will be processed from the Salt Wash Sandstone member of the Morrison Formation and pediment gravels that cover numerous hilltops in the same area that the shell embankment material is obtained, designated Zones 2 and 3 in Figure A30. Approximately 340,000 cu yd of filter, drain, cobbles, and riprap will be required.

Any concrete required at the dam will be transported from a batch plant located at the power plant as shown in Figure A24.

It is estimated that the average borrow depths will be 15 ft for Zone 1 and 20 ft for Zones 2 and 3. With allowances for estimated waste, bulking, etc., approximately 30 acres of borrow area will be required for Zone 1 and 75 acres for Zones 2 and 3.

A temporary screening plant will be located in the reservoir area for processing the Salt Wash Sandstone into filter, drain, cobbles, and riprap materials. Stockpiles will be within the reservoir area. Temporary unpaved access roads to the borrow sites will be constructed to the borrow sites as shown in Figure A30. These roads will be approximately 36 ft wide.

Construction water will be obtained from the Fremont River. Drinking water will be provided by truck from the nearest source of drinking water. Temporary electrical power will either be supplied by Garkane Power Association over an existing transmission line which parallels Highway U-24, or by portable motor generators.

It is anticipated that all construction will be done with conventional earth moving equipment used in large scale off-road projects. As much of the construction activities and laydown area as possible will be within the boundaries of the reservoir.

As construction work is completed, all temporary structures, fencing, utilities, and refuse will be removed. The cleared areas will be blended into the normal landscape of the vicinity. Borrow sites will be smoothed and graded to blend with the adjacent landscape. All temporary construction access roads, developed but not designed as permanent patrol or access roads, will be closed and similarly rehabilitated. Where applicable, cleared or graded areas will be stabilized and seeded to restore them to their original condition.

In order to pass storm and river flows during the construction of the dam, a 20- to 25-ft diameter diversion tunnel, approximately 1200 ft in length will be constructed to pass a 50- to 100-yr flood. Utilization of the tunnel for outlet and spillway functions appears practicable; however, total spillway capacity to provide protection against overtopping of the dam in a probable maximum flood will require an auxiliary spillway.

6.2.7.3 SPILLWAY SYSTEM

Spillway and outlet works systems have not been fully explored; however, it is anticipated that these systems will be determined primarily by the topographic features and construction sequence. The same design criteria as designated in Section 6.2.5.3 for the Red Desert Dam will be used for the Fremont Dam.

6.2.7.4 OUTLET WORKS

The outlet works for the Fremont Dam will be similar to those proposed for the Red Desert Dam outlined in Section 6.2.5.4.

6.2.7.5 RESERVOIR PUMPING PLANT

A pumping plant will be required to lift the water to the plant site as would be the case for the Red Desert Reservoir described in Section 6.2.5.5. The pumping plant will be enclosed in a pump house located at the toe of the Fremont Dam as shown in Figure A12. The facility will be similar to the one described for the Red Desert Dam. The pumping plant will discharge water into a single pipeline approximately 13 miles long which will convey the water to the power plant. The maximum static lift will be approximately 395 ft.

Since the location for the dam is less than 1/2 mile upstream from the proposed Red Desert Reservoir diversion works, the access, power supply, and supervisory control for the outlet and pumping plant will be similar to that proposed for the diversion works. The pipeline to convey water to the plant site will follow the access roads and state highway routes as shown in Figure A32.

6.2.7.6 RECREATION

The general plan for the reservoir, Figure A12, delineates areas which are suitable for development for recreational uses as outlined in Section 6.2.5.6 for the Red Desert Reservoir.

6.2.7.7 WATER CONVEYANCE

Except for the location of pipeline to the plant site as described in Section 6.2.7.5, the water conveyance for the Fremont Dam alternative will be similar to that proposed for the Red Desert Dam in Section 6.2.6.

6.2.7.8 RELOCATION OF ROADS

The Fremont Reservoir will require relocation of Highway U-24 for approximately 4 miles and construction of approximately 1-1/2 miles of four-wheel-drive unpaved road for access to the existing road to Cathedral Valley as shown in Figure A12. Highway U-24 is a two-lane primary highway as designated in Figure A23. Asphalt concrete and crushed aggregate will be supplied from the same source that is used for the other access roads for IPP and discussed in Section 59.3.

6.3 GROUNDWATER SYSTEM

The groundwater system includes all facilities necessary to pump and convey water from the underground source to the power plant. The system will be comprised of a number of wells for production and observation together with pumps and motors, a system of pipelines, access roads, electrical power supply, and supervisory control. The system will supply groundwater to the plant's industrial water system at motor controlled butterfly Valve V-RWH20 (Figure B34).

6.3.1 SOURCE

The source of the groundwater for IPP is the water bearing Navajo Sandstone. The Navajo Sandstone is a fine, uniform-grained, wind deposited sandstone. The Navajo Sandstone in the Project area has been warped into a bowl-shaped aquifer with a major axis of depression known as the Henry Mountain Syncline formed in a north-south direction between the volcanic Henry Mountains and the uplifted Boulder and Thousand Lake Mountains. In this area the Navajo Sandstone varies in thickness between 800 and 1000 ft. The formation is confined for the most part by the tighter marine sediment deposits of Kayenta Formation below and Carmel Formation above.

Oil and uranium explorations, in the Project vicinity, have confirmed the artesian pressures in this aquifer. In 1973, ICPA drilled and tested a 16-in. diameter water well into the Navajo Sandstone in the Red Desert. Subsequently, in 1975 IPP developed a 20-in. diameter test water well approximately 1/2 mile from the ICPA well and two additional observation wells. Extensive pumping tests and observations were conducted during the preliminary design and feasibility study to determine properties of the aquifer. These and other investigations have been incorporated in a groundwater hydrology study by IPP (Ref 4). The study has been presented to the Utah State Engineer to assist him in making a decision on allocations of groundwater to ICPA.

The results of the pumping tests and groundwater hydrology study indicate that a supply of 20,000 acre-ft annually can be obtained by a well field development. The quantity of water flowing and in storage in the aquifer is sufficient to furnish a reliable supply, although specific well yields and well field design cannot be determined for the entire region with existing data.

6.3.2 GROUNDWATER QUALITY

The quality of water supplied from the underground aquifer is presently undetermined. Water samples drawn from the various existing or Project test wells indicate a wide range of total dissolved solids varying from 740 to 2900 ppm. Analyses of representative well water samples from the Navajo Sandstone in the Project area are shown in Table 6-2.

TABLE 6-2

QUALITY ANALYSIS OF
WATER FROM THE NAVAJO SANDSTONE
(Chemical Results in Parts Per Million)

Name of Well	ICPA	Stanolind	TW1	Colt
Number of Samples analyzed by LADWP used as basis	3	1	3	8
Specific Electrical Conductance (Kx million)	3997	2990	4110	1494
pH (Laboratory	7.63	7.62	7.82	7.71
Calcium (Ca)	259	136	82	102
Magnesium (Mg)	105	46	30	56
Total Hardness as $CaCO_3$	1075	530	325	469
Sodium (Na)	495	475	737	151
Potassium (K)	4.8	4.2	4.4	5.3
Alkalnity as $CaCO_3$ (Total-laboratory)	197	248	217	211
Sulfate (SO_4)	1022	652	665	356
Chloride (Cl)	623	454	801	180
Silica (SiO_2)	12	8.5	9.8	9.4
Iron (Fe)	0.8	--	0.5	1.0
Boron (B)	0.30	--	0.4	.04
Fluoride (F)	0.54	--	1.2	.17
Nitrate (NO_3)	0.20	0.9	0.2	LT 1
Nitrite (NO_2)	0.002	--	--	--
Total Kjeldahl Nitrogen (N)	--	--	--	0.03
Phosphate (PO_4)	0.2	0.03	0.03	--
Total Dissolved Solids	2823	2008	2537	1135

The primary variation in the quality of the water samples is in concentrations of the cations, sodium and calcium; and the anions, chlorides and sulfates. These constituents are primarily formed by mixing in the aquifer of connate marine waters and solution of salts from marine sediment formation. The analyses indicate that water quality varies spatially in the aquifer. Variation with depth within the aquifer supports the theories that water qualities are better in zones of greater water movement and where not influenced by poorer quality waters in marine formations above and below the aquifer. Areal variation is also present; however, an insufficient number of wells have been drilled to determine a pattern. Generally, it is expected that water diverted closer to the recharge into the aquifer will be of better quality.

The actual quality of raw water supplied to the plant from underground sources will be determined during the drilling and testing of the water supply wells. For the purposes of this study, the poorest quality well water obtained from tests of the Navajo Sandstone, that which came from the ICPA well, was used in determining the plant water balance and water treatment (Sections 31.0 and 34.0). The quality for water from the ICPA well is that which was shown in Table 6-2.

6.3.3 WELL FIELD LAYOUT

For the purpose of the feasibility study, conservative values were assumed for a well field and spacing configuration to intercept an average of 20,000 acre-ft per year at an average pumping rate of 2 cfs per well. Based on this assumption, approximately 14 wells will be required. However, the total delivery capacity for the groundwater supply will be capable of peaked delivery of the total maximum plant water demand which is approximately 70 cfs. To meet this demand and to provide a reserve for maintenance, a total of 20 wells will be required, each with a capacity of 3.5 cfs.

A map showing the location of the groundwater application held by ICPA and the possible location of wells based upon the above assumptions is shown in Figure A20. Actual well locations and spacings will be determined as production wells are drilled and tested in order to optimize costs of well construction and operation. All necessary permits and applications will be obtained at that time.

6.3.4 WELL CONSTRUCTION

Configurations for alternative well installations are shown in Figures A21 and A22. The individual water wells will consist of drilled and cased wells. Well screens and sand packing in the water bearing formation may be necessary to reduce sand entrainment in the pumped flow. Pumps will be either line shaft or submersible turbine type with the pump bowls set far enough below the lowest anticipated piezometric water level to provide for complete submergence at peak discharge.

Well head piping, controls, and pump motor (if applicable) will be enclosed in an underground vault to protect against weather and blowing sand, and to minimize visual impact. Discharge pipelines will also be placed under earth cover to protect against freezing and accidental damage.

The diameters of well casing, pump bowls, well screen, and discharge pipeline and the depth of pump bowls will be determined primarily by the well design flow rate. As previously discussed, the final design will result from optimization of well construction and operation costs, and observation of aquifer characteristics as production wells are put into operation. For the assumed 3.5 cfs discharge rate and locations as shown in Figure A20, individual well diameters, depths, and pumping heads have been estimated as shown in Table 6-3. The criteria for selecting the proposed locations of the wells will be depth to top of Navajo, piezometric surface, location of groundwater filings, distance from plant site, and ease of access.

TABLE 6-3

GROUNDWATER WELLS

Well Number	Bore Diameter (in)	Well Depth (ft)	Maximum Pumping Head (ft)
1	26	4500	2550
2	32	1300	1497
3	26	2400	1572
4	32	1500	1420
5	32	1500	1358
6	26	1350	884
7	26	1550	734
8	26	1650	828
9	26	2000	1020
10	32	700	500
11	26	1100	600
12	26	1400	380
13	26	1400	440
14	26	2800	534
15	26	1400	802
16	26	1600	1043
17	32	800	1111
18	32	1100	1070
19	32	1100	1142
20	26	1600	985

Approximately as many smaller diameter observation wells will be required as the number of production wells to aid in the well field design and operation. These observation wells will be used to determine the water drawdown pattern in the vicinity of the production wells, predict the future drawdown pattern, and aid in determining the most efficient operational pumping of the production wells.

Permanent well sites will normally require an approximate rectangular area of 100 x 200 ft.

The electrical power supply and monitoring of the wells are described in Section 6.4.

6.3.5 WATER CONVEYANCE

The groundwater will be conveyed from the wells to the power plant by a pipeline system as shown in Figure A31 and A32. The discharge pipelines from individual wells will be connected to larger diameter collector pipelines serving groups of wells. The collector pipelines will increase in diameter toward the plant as more wells are connected.

Based upon the assumed well field layout as shown in Figure A20, the diameters and lengths of pipelines have been estimated as shown in Table 6-4.

TABLE 6-4

GROUNDWATER PIPELINES

Diameter (in)	14	18	20	22	24	26	28	32
Length (miles)	26	12	5	13	1	5	4	20

The pipeline will be located adjacent to the roads providing access to the wells and will be constructed in excavated trenches with 4 ft of earth cover for protection from freezing and accidental damage. Drain lines will be provided at pipeline ends and at intermediate sag points. Air vents and vacuum breaking valves will be provided at local summits. Check valves will be provided at each well to prevent backflow during shutdown. Gate valves will be provided at each well and at junctions of pipelines to provide isolation for maintenance and pressure tests.

6.3.6 ACCESS ROADS

Access to the wells for the purpose of construction, patrol, and maintenance will be via unpaved access roads. Existing public roads will be utilized wherever possible. Some existing roads may require improvement in order to accommodate traffic. New access roads, where suitable existing roads are not available, will be constructed in a mutual corridor with pipelines and power supply transmission lines. The typical section of these roads will be that of an unpaved access road shown in Figure A23. Access roads will generally consist of a main road providing access to a group of wells and stub roads providing access to individual wells. The main road will follow the alignment of the pipelines to the well fields as shown in Figure A31. The location of the roads will be determined after the actual location of the wells has been determined and the water conveyance system finalized. Prior to construction of any new road, IPP will meet with the appropriate governmental agencies and submit the proposed alignment for their field review. Roads developed for construction will be laid out to serve as permanent access roads. Specifications for roads will be as follows:

1. The centerline radius will be based on the turning radius required for the construction equipment, except that the radius might be reduced for roads used only during construction and where terrain would otherwise dictate excessive cuts.

2. The maximum grade will be as follows:

    a. The normal maximum road grade will be 10 percent.

    b. If the 10 percent grade requires steep side hill cuts and numerous switchbacks, the maximum grade will be increased to 15 percent.

3. Road width will be 16 ft and conform to the typical unpaved access road cross section shown in Figure A23.

4. Roads will be constructed to cross streams or washes at grade unless otherwise restricted. Roads will cross drainage bottoms level with the stream gradient. There will be no unnecessary pushing of soil into streambeds. Where culverts are required in controlled fill

crossings of stream channels, these culverts will be of adequate size to accommodate the estimated runoff for a storm with a frequency of occurring once every 10 yrs and of sufficient strength to accommodate construction equipment. Stability of the road in stream channels will be provided by construction of a concrete crossing at the elevation of the flow line.

5. Drainage ditches will be constructed where necessary, but will be held to a minimum. Where ditches are installed, provisions will be made to dispose of the accumulated water by:

   a. Channeling into wing ditches.

   b. Depositing water into stream channels above roads.

   c. Carrying water into stream channels above roads or under drains or dips, the outlets of which will be installed in a manner that will prevent erosion.

6. The roads will be constructed so that material will not be accumulated in piles. The material will be side-cast as construction proceeds in such a way that a windrow will not be created on the downhill side.

6.4 POWER SUPPLY AND SUPERVISORY CONTROL

Transmission lines will be constructed on wood poles to provide power for operation and control of the diversion works, pump works, and well fields. The pole lines will support approximately 65 miles of 69-kv class circuits and approximately 65 miles of 15-kv class circuits. Wherever possible, the 15-kv circuits will be constructed on the same poles as the 69-kv circuits. The pentachlorophenol treated poles will be 65 ft in length for the 69-kv circuits and 50 ft for the 15-kv circuits and will be embedded 7 ft in the ground. The distance between poles will average 550 ft for 69-kv circuits, 300 ft for the 15-kv circuits, and 300 ft when the 15- and 69-kv circuits are supported on the same poles. The pole lines will generally parallel the maintenance access roads and pipeline corridors. A typical section showing the 69-kv circuits adjacent to the main plant access road is shown in Figure A28. Microwave, power line carrier equipment, or lead covered communications cable will provide for the control and monitoring of the water conveyance system. If microwave is used, several reflector or antenna sites may be necessary.

6.4.1 POWER SUPPLY

At the diversion works and reservoir pumping plants, the 69-kv lines will loop into distribution substations where the voltage will be transformed to 4.16 kv and 480 volts to feed the pumps and other loads. At the well fields, the lines will loop into distribution substations where the voltage will be transformed to a 15-kv class distribution voltage. Distribution circuits will extend from the substations to the individual pumps where the voltage will be again transformed to the pump-motor utilization voltage.

6.4.2 SUPERVISORY CONTROL

Equipment will be provided to control and monitor the various components of the water conveyance systems from the plant control room, as well as from the pump and well locations. A master supervisory station will be located in the main plant. Slave stations will be located at the diversion works, reservoir pumping plant, and at the well field distribution substations. The control and monitoring signals will be transmitted to and from the main plant by microwave, power line carrier, or by lead covered communication cable. The choice between these methods will be made during the final design phase of the Project. For details of the control and monitoring of individual components of the water supply and conveyence system, refer to Section 36.5.3.

SECTION 7.0

COAL HANDLING SYSTEM

The in-plant coal handling system, shown in Figure B19, will receive, unload, weigh, and sample the train delivered coal; store adequate coal stockpiles necessary to assure a reliable coal supply to the plant; supply the required quantity and quality of coal at rates demanded by the plant; and blend different coal grades when necessary to obtain the desired coal characteristics.

The system will be based on the following assumptions: 1) the coal will be delivered five days a week with two shifts a day and 269 cars a shift, 2) the coal will be "run-of-mine 8-in." coal (coal with oversize chunks broken up to pass through an 8-in. round hole) with a wet heating value of not less than 8760 Btu/lb, 3) the moisture content will not be greater than 12 percent, and 4) the maximum demand of the four boiler units will be 1600 tons/hr.

The in-plant coal handling system will include train unloading facilities, coal conveyors, sampling and crushing equipment, and dust control equipment. All weigh scales, metering instruments, and controls between the unit train and the boiler coal silos will also be included. Equipment required for thawing frozen coal in train cars is not included in this system.

7.1 UNIT TRAIN UNLOADING FACILITY

The unit train will be unloaded by a tandem rotary car dumper capable of unloading in 2-1/2 hrs a 100-car unit train with each car having a capacity of 100 tons. The tandem rotary car dumper will consist of two single rotary car dumpers installed to unload two successive cars in the unit train. Operation of both rotary car dumpers will be from one control panel, to make the clamping and rotating sequences for both unloaders simultaneous. After the first car has been properly spotted, positioning will be automatically indexed by a single train positioner. When the tandem rotary car dumper is in operation, indexing will be two cars at a time. When only one rotary car dumper is in operation, indexing will be one car at a time. In the latter case, the rotary car dumper out of service will be disconnected from the unloading controls. When only one rotary car dumper is in service, unloading of the 100-car unit train will be accomplished in 4 hrs.

7.2 TRACK HOPPER UNLOADING, WEIGHING, AND SAMPLING

Each of the rotary car dumpers will be provided with a 150-ton track hopper located directly below the car dumpers. Two pairs of apron feeders each rated at 1500 tons/hr will remove the coal from the unloading hoppers and will feed it to belt Conveyors 1A and 1B, each rated at 3000 tons/hr, delivery to the weigh scales. Two self-cleaning magnetic separators will be positioned at the head pulleys of Conveyors 1A and 1B to assure an iron-free coal supply to the weigh scales. From the weigh scales, the coal will flow onto Conveyors 2A and 2B, each rated at 3000 tons/hr, which will transport the coal to the 750-ton yard surge bin. The transport system from the track hoppers to the yard surge bin will handle 120 percent of the anticipated maximum coal flow. This will provide for a 10 percent variation in loose coal density and a 10 percent variation in the angle of repose of coal on the belt.

A primary sampling system will take a portion of the coal stream at the head pulley of Conveyors 2A and 2B. The coal rejected from the sampling system will be recycled to the yard surge bin.

Coal in the yard surge bin can be fed to the coal crushers by two 1600 tons/hr capacity vibrating feeders or it can be diverted to the storage piles through the surge bin overflow chutes.

7.3 CRUSHERS AND PLANT SUPPLY CONVEYORS

The coal crushers will size the coal to a "97-100 percent minus 1-1/4-in." product (coal of which 97 percent or more of chunks will pass through a 1-1/4-in. round hole, but would be held on a 3/4-in. round hole screen). From the coal crushers, the coal will flow onto belt Conveyors 7A and 7B, each rated at 1600 tons/hr which will supply the coal to the boiler coal silo dual cascade belt conveyor system. The transport systems and crusher equipment from the yard surge bin to the boiler coal silos will have the capacity to fill the boiler silos in 4 hrs or less and maintain full load in the plant when one crusher or one transport system is out of service.

7.4 CASCADE CONVEYORS TO SILOS

Two cascade conveyors will be used to fill the coal silos of each pair of boiler units. When an intermediate silo and chute are full, the coal will overflow to the next section of the conveyor which will transport the coal to the next silo and so on until all silos are full. Coal flow to any silo can be stopped by closing the chute damper serving that particular silo. The last two silos of each unit will be mounted on load cells to control the feed rate of the vibrating feeders to the crushers.

7.5 DIVERSION TO STORAGE

Coal will be diverted from the yard surge bin to storage by opening a yard surge bin overflow chute feeding Conveyor 3B rated at 3000 tons/hr and another overflow chute located at a higher elevation feeding Conveyor 3A also rated at 3000 tons/hr. Conveyors 3A and 3B will discharge the coal onto a chute system that will feed the coal to either or both of the 4500 tons/hr stacker-reclaimer Conveyor 4 and the 4500 tons/hr emergency stackout Conveyor 5. Conveyor 5 will be used to divert coal to reserve storage and to form the emergency active pile in the event the stacker-reclaimer and the silo coal supply system are both inoperative.

7.6 COAL BLENDING

The in-plant coal handling system will be able to supply newly delivered coal to the coal silos. When necessary, a blend of different coal grades can be delivered to the coal silos. Blending will be done by spreading thin layers of the different coals on the active pile with the stacker-reclaimer in the stacking mode and by reclaiming whole vertical sections with the reclaimer bucketwheel when the stacker-reclaimer is in the reclaiming mode. Normally, reclaiming of coal from active storage will be done only when there is no coal in the track hoppers.

7.7 COAL STORAGE SYSTEM

The coal storage system will hold about 1,860,000 tons of coal to allow the plant to operate at rated capacity for 48 days without coal delivery. Of this total capacity, 3 days or 120,000 tons of storage will be in the 2 active storage piles, 5 days or 190,000 tons of storage will be in the small reserve Pile 1 and 40 days or 1,550,000 tons of storage will be in the large reserve Pile 1. The emergency active pile will be formed only when coal is being unloaded from a train and the stacker-reclaimer is out of service. It will have 3 days or 120,000 tons of storage capacity.

7.7.1 ACTIVE COAL STORAGE

The active coal storage piles will consist of a 2400-ft long coal pile located on each side of the stacker-reclaimer Conveyor 4. The active piles formed by the stacker will be reclaimed by the reclaimer bucketwheel at a maximum rate of 3200 tons/hr.

7.7.2 RESERVE COAL STORAGE

The reserve coal storage piles will consist of a 5-day pile (Pile 1) and a 40-day pile (Pile 2). Both coal piles will be well compacted to a density of 65 to 72 pcf to reduce the chance of spontaneous combustion. To allow maximum rainwater runoff, the top of the piles will be sloped and the sides will be treated with a surface crusting agent.

7.7.3 EMERGENCY RECLAIM AND RESERVE COAL STORAGE RECLAIM

Reclaiming of the emergency active pile and of the reserve piles will be done through a drawdown hopper feeding an apron feeder that will operate at either 1600 or 3200 tons/hr, which feeds the coal to the emergency reclaim belt Conveyor 6 rated at 3200 tons/hr. Conveyor 6 will discharge the coal to the yard surge bin.

Magnetic separators will be installed near the head pulleys of Conveyors 4 and 6 to remove any tramp iron that may have dropped into the coal while in storage. Tramp iron collected by magnetic separators will be stored in a holding bin for periodic removal.

7.7.4 BOILER COAL SILOS

Blc of Plan

All the boiler coal silos will be in-line and will be located between the turbine and boiler bays. The boiler coal silos will be designed to store enough coal for 10 hrs of full load operation. This will allow one filling cycle per shift with a minimum of 2 hrs residual coal before every feeding cycle. To assure continuous flow all sloping portions of the coal silos will be lined with stainless steel and will have a minimum slope of 70 degrees from the horizontal.

7.8 COAL DUST CONTROL

The coal dust control equipment includes dust suppression equipment, dust collection equipment, and dust prevention equipment.

The dust suppression equipment will be a chemically-treated-water spray system which will include storage tanks, pumps, piping, spray nozzles, and controls. The central portion of the treatment system will be housed in the yard surge bin building. The purpose of the chemical treatment is to improve the wetting characteristics of the water droplets.

The coal dust collection equipment includes dust hoods, enclosures, bag filters, and bag filter blowers. Collected coal dust will be recycled for use as fuel.

The dust prevention equipment includes conveyor enclosures, telescopic chutes, earth berms, and portable surface crusting spray equipment.

7.8.1 COAL UNLOADING AND TRANSPORT

Water sprays from the dust suppression equipment will be used at the rotary car dumper area everytime a coal car is unloaded. The water sprays will be directed against the airborne dust to make it agglomerate and settle rapidly. Similar sprays will also be used at the discharge points of all conveyors in operation, except the conveyors feeding the coal silos.

All conveyors, except a portion of the stacker-reclaimer Conveyor 4, will be inside covered structures. This will prevent coal dust from becoming airborne because of wind action.

7.8.2 ACTIVE STORAGE

The active storage piles will be bounded by earth berms of approximately the same height as the piles to prevent dusting due to strong winds. Water sprays from the dust suppression equipment will be used at the discharge point of the stacker conveyor to minimize dusting.

7.8.3 RESERVE STORAGE

To prevent coal dust emissions, the reserve storage piles will be capped with surface crusting agents using portable spray equipment. Coal turnover from reserve storage will be minimized by the use of two separate storage piles, one for 5-days storage and the other for 40-days storage. If for any reason, the reserve coal must be reclaimed, the small pile will be reclaimed first to reduce the dusting potential by the preservation of the large reserve storage pile.

7.8.4 SURGE BIN AND BOILER COAL SILOS

Vacuum dust collection systems will be installed for the yard surge bin and the boiler coal silos. The airborne coal dust will be collected in a bagfilter and will be returned to the coal stream.

7.9 ALTERNATIVE SILO LOCATIONS

The location of boiler coal silos described in this report is different from the location shown in the plant general arrangement drawings (Figures B5, B6, B7, B8, B10, B11, and B12). The general arrangement drawings indicate that the silos for each boiler unit are divided into two groups located on both sides of the boiler unit. This silo location was tentatively selected at the start of the feasibility study and was used for the preparation of the general arrangement drawings. However, this section of the report indicates that all the coal silos will be in line and will be located between the turbine and boiler bays. During the preparation of the text, the location of the coal silos was changed so it could result in substantial reduction in belt conveyors and dust collection equipment. The reliability of the conveyor system could be markedly increased because of this reduction.

The cost study of alternative silo locations will be made during detailed design and after the boiler contract is awarded to evaluate the installed costs and operating and maintenance costs of the boiler silo conveyor feed system, foundations and supporting structures, coal dust control system, affected boiler feed and steam piping, air ducts, and related plant equipment.

SECTION 8.0

MAIN BOILER

The boiler will be a balanced draft unit which will generate approximately 5,700,000 lb/hr of 2475 psig and 1005F main steam and 5,200,000 lb/hr of 1005F reheat steam. Boiler fuel will be pulverized coal. The boiler unit includes much of the equipment for handling water, steam, fuel, combustion air, and flue gases. The detailed design of equipment for the boiler unit will be left to the boiler manufacturer to permit him to meet design conditions with an acceptable unit reliability at a competitive cost. The general features, which are common to all designs, are described in this section.

The following are the ratings and expected performance of the boiler unit at full load:

TABLE 8-1

MAIN BOILER RATINGS AND EXPECTED PERFORMANCE

Main Steam

Flow, lb/hr	5,700,000
Pressure, psig	2,475
Temperature, F	1,005

Reheat Steam

Flow, lb/hr	5,200,000
Pressure, inlet, psig	559
Temperature, inlet, F	628
Pressure, outlet, psig	522
Temperature, outlet, F	1,005

Feedwater

Pressure, psig	2,750
Temperature, F	480

Combustion Air

Secondary air to air preheater, F	80
Excess air, %	25

Flue Gas

Flue gas temperature from air preheaters, F	260

Pulverized Coal

Fuel flow rate, lb/hr	775,000

The above ratings are based upon the use of a coal with a heating value of 10,030 Btu/lb, wet. The boiler unit will be capable of meeting the above ratings and performing as described in this section provided the fuel characteristics are within the following ranges:

Heating value Btu/lb, Dry	10,600-13,500
Btu/lb, Wet	8,760-12,970
Moisture, %	5-15
Carbon, %	53-73
Hydrogen, %	3.6-5.0
Nitrogen, %	1.0-1.2
Sulfur, %	0.5-1.0
Ash, %	4.4-12.5
Chloride, %	.01-.03
Oxygen, %	10-20
Ash analysis %	
Phosphorous Pentoxide, P_2O_5	0.04-1.3
Silica, SiO_2	44-73
Ferric Oxide, Fe_2O_3	2-11
Alumina, Al_2O_3	4-27
Titania, TiO_2	0.2-1.5
Lime, CaO	2-13
Magnesia, MgO	0.2-5.0
Potassium Oxide, K_2O	0.2-0.5
Sodium Oxide, Na_2O	0.2-3.2

8.1 WATER-STEAM FLOW PATH

High pressure water at about 2750 psi and 480F will be provided to the boiler unit at the economizer where the temperature of the water will be raised to approximately 620F. The water will then flow to the steam drum where it mixes with a water vapor mixture from the waterwalls. The steam will be separated from the water in the steam drum and will then flow to the superheater sections of the boiler where its temperature will be increased and controlled to 1005F for the main turbine high pressure section. The water in the steam drum will be recirculated to the waterwalls for additional heat absorption and vaporization.

Most of the steam supplied to the high pressure turbine will be returned to the boiler at reduced pressure and temperature for reheating to 1005F for use in the intermediate pressure section of the main turbine.

8.2 FUEL FLOW PATH

Coal, less than 1-1/2 in. in size, will be fed from the silos to the coal pulverizer for pulverizing, metering, drying, and mixing with preheated primary combustion air. The pulverized coal will then be carried by the primary air to the coal burner ports in the boiler furnace for combustion.

8.3 COMBUSTION AIR FLOW PATHS

The combustion air will be composed of two components, primary air and secondary air. The primary air makes up 20 to 30 percent of the total combustion air, and will be used both for preparing the coal and for transporting the coal to the furnace for combustion. The secondary air provides the additional air necessary to complete combustion of the pulverized coal.

Primary air will be atmospheric air supplied by primary air fans through heaters to the coal pulverizers. Some primary air will be bypassed around the heater to provide temperature control of the primary air. Depending upon boiler manufacturer's preference and the expected variability of coal properties, the heater may be either separate or part of the secondary combustion air preheaters.

The primary air will not only transport the coal from the pulverizer to the burners, but it will also prepare the coal for combustion by classifying, preheating, and drying.

Secondary combustion air will be atmospheric air supplied by the forced draft fans. The air will flow through steam air heaters for preheating, and then to the air preheaters for further heating to the proper temperature for combustion in the boiler.

8.4 FLUE GAS FLOW PATH

The pulverized coal will mix with the air and burn in the furnace. The products of combustion (flue gases) will radiate heat to the waterwalls and flow to the backpasses of the boiler, superheater, reheater, and economizer sections, where additional heat will be conducted to the steam and to the incoming water. The flue gases will then leave the boiler and pass through the electrostatic precipitators for particulate removal and then to the air preheater where additional heat will be transferred from the flue gases to the incoming combustion air. The flue gases will then flow through the remaining portion of the draft system for additional cleaning and discharge to the atmosphere.

8.5 PRIMARY AIR FANS

The air for drying the pulverized coal, for transporting the coal to the burners, and for partial combustion of the coal will be supplied by two primary air fans per boiler unit. Each fan will supply air at the rate of 853,000 lb/hr and a discharge pressure of approximately 40 in. of water above ambient pressure based upon a plant elevation of 4950 ft above sea level and an ambient temperature of 80F.

The fan design will be tested at the factory to perform satisfactorily at a minimum of 125 percent of design weight flow, 150 percent of design static discharge pressure, and 25F above design temperature. Each fan will be capable of supplying air at the rate of 1,070,000 lb/hr and a discharge pressure of approximately 60 in. of water above ambient pressure based upon an elevation of 4950 ft and an ambient temperature of 105F.

Each fan will be a centrifugal type fan with backwardly curved air foil blades. The fans will be provided with multi-blade outlet dampers for isolating the fans and inlet vanes for controlling air flow. Fan noise will be kept below 90 dBA at the fan by the use of inlet silencers.

8.6 AIR PREHEATERS

Combustion air will be heated to the proper temperature for combustion in the boiler by regenerative air preheaters utilizing heat from the flue gases. The air preheater is a heat storage device which alternately absorbs and releases the heat as the flue gas and combustion air alternately pass around the heater elements. Secondary combustion air temperature will be increased above 550F and flue gas temperature will be reduced to approximately 260F. In some designs primary air can also be heated to the proper temperature by the same air heater.

Each air preheater will be driven through a flexible coupling and speed reducer by an electric motor rated at approximately 20 hp. Operation of the air preheater will be controlled from the control room. An auxiliary air motor drive will also be provided for emergency operation of the air preheater in the event of an electric motor drive unit failure.

The air preheater will have automatically operated cleaning devices using air as the cleaning medium as well as having water washing capability. Air heater plugging and corrosion will also be minimized by operation of the air preheaters with average cold end temperature above 155F. Average cold end temperatures will be maintained above 155F by steam air heaters to prewarm the incoming combustion air for air preheater protection.

8.7 PULVERIZED COAL SUPPLY SYSTEM

The pulverized coal supply system will include coal pulverizers, valves and piping, coal stoppage safeguards, fire protection equipment, and automatic controls between the coal silo outlet and the coal burner supply piping. The design and control of the coal supply system will be in accordance with the National Fire Protection Association (NFPA) recommendations contained in their standards, NFPA 60, Pulverized Feed Systems and NFPA 85e, Pulverized Coal-Fired Multiple Burner Boiler-Furnaces.

Coal will be delivered from the coal silo to the coal feeder through the head seal downspout. The head seal downspout will be sized to minimize coal stoppage due to hangups, arching, or fluidizing. Two nuclear monitors will be installed to monitor the flow of coal to the feeder and verify that coal flow stoppage has not occurred. If a loss of coal flow to the feeder is detected by the nuclear monitors, the feeder will be automatically shut down before the head seal is broken. The nuclear monitors will be of the gamma radiation source and Geiger-Muller tube detector type equipped with adequate radiation shielding. The downspout will be provided with a flanged pipe bypass for downspout cleanout.

Coal feeders will feed and meter the coal flow to the pulverizers. The feeder will be provided with coal stoppage switches to stop the feeder and automatically alarm when there is coal flow stoppage or when there is coal flooding in the feeder discharge. Feed indicators and integrators will be provided for either local or remote monitoring. Operation of the feeders will be automatically controlled by the boiler combustion control system. The coal feeders will be designed to withstand an internal static pressure of 50 psi. Provisions will also be made for a fire control system, using water or carbon dioxide, to be installed later if required.

The coal discharged by the feeder will flow into a coal pulverizer, through an outlet downspout provided with a tight shutoff valve at the feeder discharge. The pulverizers will pulverize the coal to the desired fineness of at least 70 percent through a 200 mesh U.S. standard sieve. The pulverizers will also use primary combustion air to meter, classify, dry, and preheat the pulverized coal in preparation for combustion in the furnace. The number and size of pulverizers depend upon pulverizer design, boiler design, and expected coal properties; but typically seven or eight pulverizers will be required during normal operation. The pulverizers will be capable of providing at least 440 tons/hr of pulverized coal per boiler unit. In addition, sufficient spare pulverizers will be provided to permit normal pulverizer maintenance.

The coal pulverizers will be either ring roll and roller mills, ball bearing mills, or ball-tube mills. Grinding parts will be of impact and wear resistant materials. Each pulverizer will supply the pulverized coal primary air mixture to several burners through coal burner piping. The burner piping will be orificed to equalize the supply of coal to all burners. Because the coal air mixture is erosive, the coal burner piping will be provided with replaceable wear plates at bends. Provisions will also be made for the installation of nozzles for internal fire protection without drilling through the pulverizer casing.

8.8 IGNITORS AND WARM-UP GUNS

The boiler unit will be equipped with ignitors and warm-up guns utilizing No. 2 fuel oil. The warm-up guns will be used during unit start-ups providing heat input until primary and secondary air temperatures have increased sufficiently to permit operation with pulverized coal. The ignitors will be used for igniting the pulverized coal in the main burners and the No. 2 oil in the warm-up guns. Depending upon boiler design, the ignitors and warm-up guns may also be used for flame proving of the pulverized coal burners until a sufficient heat input rate is achieved so that combustion of the pulverized coal may be monitored directly.

Ignitor size will depend upon boiler design and the number of burners, but each ignitor is expected to be in the heat input range of from 3 million to 10 million Btu/hr. Warm-up gun size will be determined by the boiler design, and will be of sufficient capacity to provide boiler start-up operation until pulverized coal burners can be placed in service.

Both the ignitors and warm-up guns will use air to atomize the fuel oil. In this feasibility study, it is considered that atomizing air will be supplied by warm-up gun air compressors in the plant's compressed air system. During detailed design of the plant, however, an evaluation will be made of eliminating the warm-up gun compressors and supplying atomizing air from the sootblower air compressors.

Maximum atomizing air flow rates for ignitor and warm-up gun operation will occur during unit start-up, at which time approximately 1200 scfm of air will be required. Compressed air will also be used for purging oil from the ignitors and warm-up guns as part of their normal shutdown sequence.

Burner operation will be continuously and automatically monitored and controlled by the burner control system, providing for safe burner operation. Control and operation of the burners, ignitors, and warm-up guns will be in accordance with NFPA 85e, Pulverized Coal-Fired Mutiple Burner Boiler-Furnaces.

During detailed design of the plant, evaluation will also be made of using heavier fuel oils in place of No. 2 oil or as an alternate fuel for the ignitors and warm-up guns.

8.9 FURNACE, WINDBOX, AND HOPPERS

Combustion of the pulverized coal and initial combustion heat transfer will take place in the boiler furnace where sufficient cooling of the combustion gases will take place to reduce slagging in the back passes. In some boiler designs, the furnace has a water-cooled division wall which divides the furnace into two halves and increases the waterwall radiative heat transfer surface without increasing furnace volume. Whether a division wall is provided or not, the windbox will provide balanced secondary air flow to the furnace and all burners. Balanced air flow will be maintained to all burners even with one forced draft fan out of service.

The furnace will be the dry bottom type wherein the temperatures near the furnace hopper are low enough to solidify the bottom ash for collection in the furnace hopper. An additional quantity of ash is carried through the boiler unit convective passes, a portion of which is collected in the economizer hopper. The total ash collected in the furnace and economizer hoppers will be approximately 20 percent of the total coal ash.

The furnace and economizer hoppers and their supports will be designed to carry the weight of the ash or water when full, the weight of the ash and water sluice tank (economizer ash hopper), and the weight of directly attached auxiliary equipment such as valves, ash feeding equipment, gates, and conveyor piping.

The inclined surfaces of the economizer hoppers will have a minimum slope of 60 degrees from the horizontal. The total combined storage capacity of the economizer hoppers will be 80 tons of ash with an expected specific weight of approximately 45 pcf.

The inclined surfaces of the furnace hoppers will have a minimum slope of 50 degrees from the horizontal. Each hopper will have a minimum throat opening width of 3 ft in the bottom. A stainless steel seal plate will be seal welded around the hopper periphery.

8.10 PRESSURE PARTS

Boiler pressure parts include the furnace and back pass radiative and convective heat transfer surfaces, water and steam piping, and headers and drum. All pressure parts will meet the ASME Boiler and Pressure Vessel Code, Section I. The heat transfer surfaces will be arranged and spaced to minimize erosion and slagging and to facilitate cleaning by air blower devices in locations where deposit accumulation is anticipated.

The boiler furnace will have water cooled walls which absorb heat primarily by thermal radiation and transfer the heat to the water-steam mixture by convection. A water circulation system will be provided to maintain adequate water flow in the waterwall tubes for tube cooling. The waterwall will cool the combustion gases sufficiently before they reach the convection section so that deposits can be controlled in the convection section by sootblowers. The waterwalls will be of tube and membrane type construction which form a seal around the furnace. The seal reduces air and flue gas leakage. Membrane waterwalls also reduce maintenance by reducing exposed refractory in the furnace and reduce boiler erection costs by factory fabrication of the tube panels.

The steam drum will provide dry steam with a minimum of solids carryover to the superheating sections of the boiler, and water, free of steam, to the furnace wall circulation system. Besides equipment for moisture and solids separation, the drum will be provided with blowdown collection equipment to limit solids build-up by continuous blowdown and with water level gages having remote water level indication in the main control room.

Some boiler manufacturers design the boiler to permit natural waterwall circulation; others design to assist waterwall circulation with pumps. If the boiler unit utilizes pumps to assist waterwall circulation, then a standby pump will be provided to permit continued and normal boiler operation in the event that one pump is not operable.

8.11 STEAM TEMPERATURE CONTROL

Main steam and reheat steam temperatures will be automatically controlled at 1005F. The design steam temperatures will be maintained through the load range from 60 percent to full load operation.

A number of methods are available to control steam temperature including attemperation spray, burner tilt, gas recirculation, gas bypass, and excess air. Steam attemperation will be used to control main steam temperature during unit operation and reheat steam temperature during operating transients and abnormal operating conditions. Attemperation spray will not be used for reheat temperature control during normal operation because of its detrimental effect on cycle efficiency. Burner tilt, gas recirculation, gas bypass, and excess air all control steam temperature by changing heat absorption rates in various sections of the boiler with negligible cycle efficiency changes.

Boiler manufacturers usually offer a combination of methods for steam temperature control. Excess air, however, will not be used for temperature control because of the desire to maintain low excess air levels for NOx control. Burner tilt and gas recirculation, designed to be compatible with NOx control techniques, will be considered for steam temperature control.

8.12 SOOT BLOWING SYSTEM

Soot blowers will be provided for cleaning the heat transfer surfaces of the boiler furnace, convection passes and the air preheaters. Compressed air will normally be used as the soot blowing medium, and auxiliary steam will be used as a backup soot blowing medium.

Each boiler unit will have approximately 200 soot blowers, requiring differing air flow rates and operating times to perform the cleaning operation. The cleaning operation will be automatically performed and may be controlled from the main control room. Soot blowing is expected to occur once each 8-hr shift and requires about 6 hrs to complete. Blower operation will be sequenced to levelize the compressed air requirements.

Compressed air will be supplied by one compressor for each boiler unit. Each compressor will be rated at approximately 4500 hp, have five stages, and be capable of providing approximately 14,000 scfm. Each soot blower will be driven by a 1-1/2 hp electric motor.

Although only one compressor will be furnished per boiler unit, the soot blower systems of all units will be intertied to provide backup compressed air in the event a compressor is not operable. Additional soot blowing reliability will also be provided by substituting auxiliary steam for compressed air in the event that compressed air is unavailable for soot blowing.

SECTION 9.0

DRAFT SYSTEM

The draft system, as shown in Figure B20, will be a balanced draft system for each boiler unit consisting of two primary air fans, two forced draft fans, two steam air heaters, two air preheaters, electrostatic precipitators, four induced draft fans, flue gas scrubbers with flue gas reheaters, a stack, and associated ducting, dampers, and expansion joints. Details of the forced and induced draft fans, steam air heaters, ducting, dampers, expansion joints, and stacks are covered in this section. Details of other equipment are covered in other sections of this feasibility study.

Atmospheric air will be conducted by the primary air ducting from the primary air fans through heaters to the coal pulverizers where the air will dry the coal and then transport the coal to the burners for combustion. Additional atmospheric air (secondary air) will be conducted by secondary air ducting from the forced draft fans through the steam air heaters for preheating, then to the air preheaters for further heating to the proper temperature for combustion in the boiler. Flue gases will leave the boiler through flue gas ducting and enter the electrostatic precipitators for particulate removal. The flue gases will then preheat the incoming air in the air preheater and flow, at reduced temperature, to the induced draft fans where it will be circulated to the scrubbers for SO_2 removal and additional particulate removal. After leaving the scrubbers, the flue gases will be reheated and discharged through the stack.

9.1 FORCED DRAFT FANS

The air flow from the forced draft fans will provide for sufficient secondary combustion air, including the required excess air, and anticipated air heater leakage, to operate the boiler at its maximum continuous rated output of 5,700,000 lb/hr of steam. The two forced draft fans will each supply air at the rate of 3,420,000 lb/hr and a discharge pressure of 15 in. of water above ambient pressure based on an elevation of 4950 ft and an ambient temperature of 80F.

The fan will perform satisfactorily at a minimum of 125 percent of design weight flow, 150 percent of design static discharge pressure, and 25F above design temperature. Each fan will therefore be capable of supplying air at the rate of

4,280,000 lb/hr and a discharge pressure of 22.5 in. of water above ambient pressure based upon an elevation of 4950 ft and an ambient temperature of 105F.

The fans will be centrifugal type with backwardly curved air foil blades and water-cooled bearings. The fans will be provided with multi-blade outlet dampers for isolating the fans and inlet vanes for controlling air flow. The inlet vanes will permit flow control from 10 percent flow to full load flow. Fan noise will be kept below 90 dBA at the fan by the use of inlet silencers.

Each fan will be direct driven by a horizontal, totally enclosed, squirrel-cage induction motor rated at 5000 hp and connected to the motor by a flexible coupling.

9.2 INDUCED DRAFT FANS

Induced draft fans will be designed for the same boiler operating conditions as the forced draft fans, but they will handle flue gas at 260F. Each fan will handle flue gas at the rate of 2,300,000 lb/hr and provide a differential pressure of 29 in. of water. The fan will perform satisfactorily at a minimum of 120 percent of design weight flow and 130 percent of design static discharge pressure. Each fan will therefore be capable of supplying 2,760,000 lb/hr of air at a differential pressure of 38 in. of water.

The induced draft fans will be centrifugal type fans with backwardly curved air foil blades and oil-cooled bearings. The fans will have inlet and outlet multi-blade dampers for fan isolation. Flow control will be accomplished by varying the turbine drive speed. Induced draft fan noise will be attenuated by the fan inlet and outlet ducts which will keep the sound level below 90 dBA at the ban.

9.3 INDUCED DRAFT FAN TURBINES

Each pair of induced draft fans will be driven by a condensing steam turbine connected to the fan through speed reduction gears. Each steam turbine will normally provide approximately 11,000 hp and use approximately 92,000 lb/hr of steam. The steam will normally be supplied from the last stage of the intermediate pressure section of the main turbine and will exhaust to a separate induced draft fan turbine condenser. Steam will also be supplied from the auxiliary steam system for unit start-up and for induced draft fan operation following a boiler trip. If auxiliary steam is not avaiblable following a boiler trip, induced draft fan operation may also be maintained by use of the residual heat stored in the boiler to supply steam by way of the main steam line.

The fan turbine system will have a turning gear and zero speed disconnect coupling which will be controlled from the main control room. Individual self-contained lube oil systems, each with a lube oil reservoir, pumps, and two full-capacity oil coolers, will be provided for each fan turbine. The two fan turbines for each boiler unit will share a single lube oil purification unit.

9.4 STEAM AIR HEATERS

Secondary combustion air will be heated in recuperative steam air heaters located at the discharges of the forced draft fans. The steam air heaters will raise the temperature of the combustion air flowing to the air preheaters to prevent excessive cooling and condensation of corrosive vapors on the cold end of the air preheaters. Heating the combustion air supplied to the air preheater maintains the air preheater cold end average temperature above 155F, the minimum temperature recommended for the expected flue gas environment. Steam air heating of the combustion air serves another purpose not normally necessary for steam generating units. The heating of the combustion air supplied to the air preheater will reduce the variations in flue gas temperatures entering the S02 scrubber due to variations in ambient air temperatures. This control of flue gas temperature will permit reduced maximum and average water evaporation rates in the scrubber system.

The steam air heaters will be capable of maintaining secondary combustion air temperatures to the air preheater at 90F. Each steam air heater will normally use about 30,000 lb/hr of steam but will be capable of using as much as 65,000 lb/hr of steam to raise the temperature of the secondary combustion air 93F. The steam will normally be supplied from the last stage of the intermediate pressure turbine. The steam will condense in the heater, to be collected in a hotwell and then returned to the cycle through the induced draft fan turbine condenser.

Alternate methods of supplying steam and returning the condensate to the cycle are available. Steam could be supplied to the steam air heater from an extraction point on the induced draft fan turbine or from the low pressure section of the main turbine. The condensate could be returned to the cycle through the feedwater heater drain system. The alternatives make more efficient use of the steam but require additional equipment. These alternatives will be further evaluated during detailed design to determine the optimum economic steam supply and condensate return locations.

The steam air heaters will have copper nickel tubes with fins extending into the air steam. Steam will be emitted through an inner tube positioned in the center of the finned tube. The inner tube will have orifices to provide equal steam distribution along the entire length of the outer tube where the steam is condensed. The tubes will be sloped to aid condensate drainage from the tubes to the collecting headers.

9.5 DUCTS

Air and flue gas ducts will be used to conduct the air and flue gases through the system. The ducts will be air and gas tight, with expansion joints to relieve expansion stresses and guillotine dampers for equipment isolation. Pressure losses in the ducts will be minimized by the use of turning vanes and a design air flow velocity of approximately 40 fps.

All ducts, except the cold flue gas ducts, will be designed for pressures of at least 50 in. of water below and 30 in. of water above ambient pressure. The cold flue gas ducts downstream of the induced draft fan are not subjected to significant negative pressures but could experience higher positive pressures. The cold flue gas ducts will be designed for a positive pressure of at least 70 in. of water above the ambient pressure.

All hot air and hot flue gas ducts will be insulated with block insulation and an aluminum skin to reduce heat losses. All cold flue gas ducts will be internally lined with 1-1/2 in. of gunite for corrosion protection and insulation. Where necessary all ducts will be further insulated to reduce heat loss and to protect personnel.

9.5.1 COLD AIR DUCTS

The cold air ducts will be relatively short ducts which conduct secondary air from the forced draft fan discharge through the steam air heaters to the air preheater inlet. Air temperature in the cold air ducts is not expected to exceed 140F.

9.5.2 HOT AIR DUCTS

The hot air ducts will conduct the heated secondary combustion air from the air preheaters to the boiler windbox. Hot air ducts will be similar to the cold air ducts except that the air temperatures could reach 600F.

9.5.3 HOT FLUE GAS DUCTS

The hot flue gas ducts will conduct the flue gases from the boiler economizer through the electrostatic precipitators to the air preheaters. A crossover connection will be provided between the banks of precipitators and air preheaters to help balance flows to the air preheaters.

Uniform flow distribution and particulate loading is very important for proper operation of the electrostatic precipitators. These ducts will be carefully designed by the use of model tests to provide even flue gas distribution and levelized particulate loading to the precipitators. Flow proportioning dampers will also be provided at the precipitators for fine tuning adjustment of the gas flow to ensure proper flow distribution to the precipitator sections.

The electrostatic precipitators, as described in Section 10.1, will be mechanically sectionalized with guillotine dampers to permit isolation of precipitator sections for maintenance during unit operation. The hot flue gas ducts will be designed for temperatures of at least 750F.

9.5.4 COLD FLUE GAS DUCTS

The cold flue gas ducts will conduct flue gas from the air preheater through the induced draft fans and scrubber system to the stack for discharge to the atmosphere. A bypass around the scrubber system is also provided for unit start-up. The flue gas which will split for flow through the two air preheaters will be combined in a common header before flowing to the scrubber system. Proportioning dampers will provide balanced flow and equalize loading to the scrubber system.

The scrubber system, as described in Section 10.2, will consist of five scrubber modules per unit, each composed of four normally operating scrubber stages. Each module will have a standby stage which could be placed in service if another stage is not operating properly. The standby stages also will permit the removal of one module from service without significantly reducing scrubber efficiency. Guillotine dampers are provided for module isolation to permit maintenance of scrubber modules during unit operations.

Cooled flue gas from the scrubber stages, saturated with moisture, will be reheated to 170F in the flue gas reheaters for discharge through the stack. The reheating improves flue gas dispersion by decreasing gas relative humidity and increasing buoyancy.

Reheating will be accomplished in steam coal recuperative heaters located at the discharge end of each scrubber module. Heating steam will be provided from the last stage of the intermediate pressure turbine; the same steam supply as for the induced draft fan turbines and steam air heaters. The steam will condense in the reheater, and the drains will flow to the induced draft fan turbine condenser.

All cold flue gas ducts will be designed for temperatures of at least 400F.

SECTION 10.0

MAIN BOILER EMISSION CONTROL SYSTEM

The emission control systems will be designed to meet all applicable federal and state emission regulations. The selected systems will employ the best practicable control technology. In addition to meeting applicable emission standards, the emission control system will ensure that the plant meets all federal primary and secondary ambient air quality standards as well as the proposed more stringent significant deterioration increment for Class II areas. The air quality standards for Class II areas are presented in Table 10-1.

The emission control system will be specifically designed to control nitrogen oxide (NOx), SO2, and particulate emissions for which both stack emission and ambient air quality standards have been established. Table 10-2 compares estimated emissions from the power plant with existing regulations. Emission reductions of SO2 and particulate matter due to these control systems are also shown in Table 10-2.

To ensure proper operation of the emission control systems, stack gas monitors will be installed to continuously measure and record SO2 and NOx emissions as well as plume opacity. These monitors will provide records of plant emissions which will be available to appropriate regulatory agencies.

The selection of specific control systems is based upon the best practicable technology currently available. Technical review of advances in emission control systems will be made prior to final design. This technical review is especially important with regard to SO2 emission control systems, many of which are currently being developed.

TABLE 10-1

AIR QUALITY STANDARDS
FOR
CLASS II DETERIORATION INCREMENT

	Micrograms Per Cubic Meter
Particulate matter	
Annual geometric mean	10
24-hr maximum	30
Sulfur Dioxide	
Annual arithmetic mean	15
24-hr maximum	100
3-hr maximum	700

TABLE 10-2

PLANT EMISSIONS

	Estimated Stack Emissions	Federal Regulations	Abated Plant Emissions	Unabated Plant Emissions
	(lb/million Btu)		(tons/hr)	
Average Coal*				
Sulfur dioxide	0.1	1.2	1.58	15.80
Particulates	0.02	0.1	0.26	102.4
Nitrogen oxide	0.7	0.7	--	--
Minimum Grade Coal				
Sulfur dioxide**	0.2	1.2	2.92	29.20
Particulates***	0.03	0.1	0.44	175.0
Nitrogen oxide	0.7	0.7	--	--

*Corresponds to 0.55 percent sulfur and 8.4 percent ash content with higher heating value (wet) of 10,100 Btu/lb.

**Corresponds to 1.0 percent sulfur content with higher heating value (wet) of 10,100 Btu/lb.

***Corresponds to 12.5 percent ash content with higher heating value (wet) of 8760 Btu/lb.

10.1 PARTICULATE MATTER CONTROL SYSTEM

Electrostatic precipitators, as shown in Figures B6 and B20, will be provided to remove 99.5 percent of the fly ash resulting from the combustion of coal. This collection efficiency will meet both federal new stationary source performance standards and Utah State regulations on plume opacity. Furthermore, the design will demonstrate the employment of the best practicable control technology in removing particulates and is the prevailing particulate removal method adopted by most new power plants using low sulfur coal as fuel. In combination with particulate matter removal in the SO2 scrubber, a total of 99.75 percent of the particulates will be removed.

The hot electrostatic precipitator was selected over several particulate removal systems that are currently available. Removal systems considered included the hot electrostatic precipitator, cold electrostatic precipitator, fabric filter, and venturi scrubber. Selection was based on overall advantages of the hot electrostatic precipitator when efficiency, performance, component life, cost, and operating experiences were evaluated for the fuel and operating conditions expected. Hot electrostatic precipitators have been successfully operated on low sulfur coal-fired power plants.

The precipitators will be designed for coal of maximum ash content and the following flue gas conditions:

9,420,000 lb/hr flow
5,400,000 acfm at 700F
Design temperature - 700F
Maximum gas velocity - 6 fps through precipitators

Electrostatic precipitators for each boiler will consist of four double-chamber, horizontal gas flow type, installed between the economizer of the boiler and the air preheater. Particles suspended in the flue gas are removed by electrostatically charging the particles through the corona effect of discharge electrodes. Under the strong influence of an electrical field, the charged particles become separated from the gas, and travel to collecting plates. The resulting dust layer is compacted and held in place by electrostatic forces until removed from the collecting plates by rapping.

The performance of electrostatic precipitators is closely related to the electrical resistivity of fly ash which, in turn, is a complex function of fly ash temperature, chemical and physical properties, and the presence of certain chemical components in the flue gas. Electrostatic precipitators operate efficiently with a fly ash resistivity ranging from 100 million to 10 billion ohm-centimeters. If the precipitator were installed downstream of the air heater (cold electrostatic precipitator) where the temperature ranges from 250F to 350F, the fly ash resistivity would be more than 50 billion ohm-centimeters which is in excess of the permissive range. The high resistivity fly ash causes a high voltage drop across the collected dust layer and reduces the strength of the corona effect required to charge the dust particles.

To avoid excessive fly ash resistivity at the temperature range (250F to 350F) of cold electrostatic precipitators, coal must have 2 to 3 percent sulfur content or the flue gas must have 15 to 18 ppm of sulfur trioxide. However, when using coal with less than 1 percent sulfur (to minimize SO2 emissions) the problem is compounded. Therefore, a hot electrostatic precipitator will be installed ahead of the air preheater with an expected temperature range of 650F to 850F. At these elevated temperatures, fly ash resistivity decreases; correspondingly, adhesive characteristics are reduced thus enhancing plate cleaning with lighter rapping. Furthermore, the sulfur content of the flue gas makes little difference at these temperatures. The sensitivity of the precipitator to normal fluctuations in operating conditions is greatly reduced, making it more reliable.

Additionally, in a hot precipitator, ash hang-up in the hopper is eliminated ensuring free flow of the ash. The surfaces of the air preheater will be exposed only to clean gas, minimizing wear and maintenance, and improving heat transfer characteristics.

The precipitators for each boiler will be equipped with eight separate gas-tight chambers, at least 64 bus sections, 32 high voltage supplies, and a minimum of four fields for each precipitator. These design features will permit sectionalization of the precipitators into smaller independently controlled sections. During electrical equipment failure, the problem bus section can be isolated and deenergized, allowing continuous operation of the precipitators. The benefits of sectionalization are that it provides improved reliability and maintenance.

The discharge electrodes will be of the rigid frame type and the collecting electrodes will be solid steel plates. The rigid frame electrodes are preferred over weighted wire electrodes, which are susceptible to breakage.

The rapping system for cleaning discharge electrodes and collector plates will be a mechanical type system of the hammer and anvil or drop-rod single impact design, utilizing electric motor drivers. A maximum of two collecting plates per field will be rapped at any instant to reduce stack puffs and minimize reentrainment of the particles. The hoppers, which collect the dust rapped from the collecting plates, will have a 12-hr storage capacity at the design flow and maximum inlet dust loading.

Automatic precipitator controls will be of the high speed, silicon controlled rectifier or magnetic-amplifier type, designed to maintain the optimum precipitator voltage and current for variation in rate of flue gas flow and particle content. A REMOTE-OFF-ON switch will be provided on a control cubicle and when set at the REMOTE position will enable selection of an automatic or manual control mode of operation from the control room. In the manual control mode the unit control room operator will be able to control the electrical performance of the collector manually. In the automatic control mode, the automatic regulating unit located in the control cubicle will automatically control performance of the collector. All major precipitator problems will be annunciated in the control room.

10.2 SULFUR DIOXIDE CONTROL SYSTEM

The SO2 control system, as shown in Figures B10, B20, and B48, will be designed to remove 90 percent of the SO2 produced in the boilers and 50 percent of those particulates not collected by the electrostatic precipitator. This control of SO2 emissions will meet current Utah State regulations and will employ the best practicable control technology. The additional removal of fine particulates, which have a strong influence on opacity, will ensure that the plant will meet stack opacity regulations.

A lime throwaway wet scrubbing process utilizing a horizontal scrubber will be used. This process was compared with limestone, dual alkali, magnesium oxide regenerative, Wellman-Lord regenerative, and catalytic oxidation processes. The horizontal scrubber was compared with numerous scrubber designs including the vertical spray tower, turbulent contact absorber, packed towers, and marble bed-type scrubbers. Many other SO2 control system concepts are currently in the early stages of development and, therefore, lack adequate operating experience for proper evaluation (Ref 1 to 4).

The selection of the lime process is based on the availability of absorbent material, applicable operating experience of the process, reliability, waste disposal requirements, ability to remove 90 percent of the SO2 in the flue gas, and economics. For application to IPP, the use of lime or limestone will be the most economical.

Benefits of the lime process rather than limestone include reduced quantities of material to handle, reduced quantities of wastes, reduced water consumption, reduced maintenance, and greater reliability. Furthermore, the use of lime with the horizontal spray scrubber significantly enhances the reliability and reduces the overall operating costs of the scrubbing process.

Selection of the horizontal spray scrubber was based upon the characteristic low flue gas pressure drop across the scrubber which will minimize power requirements and the need for additional induced draft fans, the demonstrated high reliability and SO2 removal efficiency for low sulfur coal, simplicity of design and operation, the lack of scaling problems when using lime, and the demonstrated ability to collect fine particulates.

The process flow diagram, Figure B48, shows the basic design of the scrubber system which will be used for SO2 control (Ref 5 and 6). The control system is designed to minimize raw water makeup requirements, meet the objectives of 90 percent SO2 removal, provide reliable operation, and minimize waste products.

Instruments, controls, electrical switchgear, and a laboratory for each boiler SO2 control system will be housed in a separate scrubber area control building as shown in Figure B10.

10.2.1 FLUE GAS TREATMENT SUBSYSTEM

Flue gases from each boiler will be treated by five individual horizontal spray scrubber modules, each module sized to process one-fifth of the maximum expected flue gas flow. Design flue gas velocity through the scrubber will be 20 fps. Guillotine-type dampers will be installed on individual scrubber module ducts to allow each module to be operated independently. The modules providing five parallel gas flow streams will be located downstream of the individual draft fans.

The flue gases are initially presaturated with water upon entering the horizontal scrubber module. This presaturation will cool the flue gases, thus improving the chemical reaction of SO2 with lime. Furthermore, presaturation of the flue gases will prevent scaling problems associated with the wet-dry interface area of the scrubber. Presaturation will consume over 90 percent of the water requirements of the scrubbing system. To minimize the raw water requirements, presaturation water will be obtained from cooling tower blowdown and recycled scrubber system water.

In each of the scrubber modules, saturated flue gases will normally pass through four separate spray stages where a lime ($Ca(OH)_2$) slurry is sprayed perpendicular to the flow of the flue gases. A fifth spray stage will be provided as a spare. The absorption of SO2 in the flue gas is accomplished by contact with the lime resulting in the chemical reaction of calcium ions with the SO2. The overall chemical reactions taking place in this process are as follows:

$$Ca(OH)_2 + SO_2\,(g) \rightarrow CaSO_3 \cdot 1/2\ H_2O(s) + 1/2\ H_2O$$

$$Ca(OH)_2 + SO_2\,(g) + H_2O + 1/2\ O_2 \rightarrow CaSO_4 \cdot 2\ H_2O(s)$$

The lime slurry sprayed into each scrubber stage is collected in bottom hoppers and fed by gravity to a slurry reaction tank where the above chemical reactions go to completion. Fresh lime is added in the reaction tank as a slurry and pumped back to the scrubber modules. To achieve 90 percent SO2 removal, each stage of the scrubber will be supplied with a maximum lime slurry flow of 8000 gpm. This flow corresponds to the boiler operating at full capacity, with lower capacities requiring smaller slurry flow rates. The lime slurry will contain approximately 10 percent solids.

The scrubber module, in addition to removing 90 percent of the SO2, will also remove 50 percent of the fine particulates not collected by the electrostatic precipitator. These particulates, which are of very small size, can have a significant effect on stack opacity.

A fifth spray stage will be included with each scrubber module to ensure reliable operation. Through use of this fifth spray stage, any spray stage of the scrubber module may be shut down for maintenance without affecting the overall SO2 removal performance of the module. Additionally, one entire scrubber module can be shut down while still maintaining a total of 20 spray stages for scrubbing. The incorporation of a fifth spray stage in each scrubber module provides a high degree of flexibility in maintaining the entire SO2 removal system, while minimizing the number of spare slurry pumps required for reliable operation.

The scrubber contains no moving parts and is designed to be relatively free from surfaces which could cause scaling and plugging problems. By reducing such potential problems, reliability is enhanced without resorting to complex dual alkali processes.

After mixing and reacting with the lime slurry, the flue gases contain entrained droplets of slurry and water which must be removed before the flue gases can be reheated and discharged out of the stack. A two-stage vertically-mounted chevron-type demister will be provided near the outlet end of each scrubber module to remove these droplets. The demister baffles will be washed approximately every 4 hrs at a rate of 600 gpm to prevent the buildup of solids. A sequential demister washing schedule for each of the five modules will allow the use of a single wash pump with a spare pump provided for reliability.

The demister wash water will be supplied by cooling tower blowdown, thus minimizing raw water requirements while keeping the dissolved solids content at a reasonable level. The wash water from the demister will be gravity drained into the recycle hold tank. With the selection of direct reheating of the flue gases, effective removal of entrained solids and water is important for preventing corrosion of flue gas reheater tubes.

Before leaving each scrubber module, the flue gas will be reheated from approximately 116F to 170F by means of direct steam reheat tubes. Reheating of the flue gases will prevent condensation of moisture in the stack, as well as preventing condensation in the plume at the top of the stack. Condensation of flue gases exiting the stack would result in a loss of plume buoyancy and reduced plume dispersion.

Steam for reheating the flue gases will be supplied from the last stage intermediate pressure section of the main turbine. Each module will use approximately 23,000 lb/hr of steam at a temperature of 715F and pressure of 145 psi. The resulting condensed steam will flow to the intermediate pressure section of the main turbine condenser.

10.2.2 LIME SUPPLY SUBSYSTEM

The lime supply source, subsequent transporting of lime to the plant site, and storage within the plant are discussed in Section 11.0.

Lime will be supplied from the day storage bins of each unit by gravity feed to the lime slakers located below the storage bins. The lime supplied to the slaker will be a high calcium pebble quicklime of at least 90 percent calcium oxide (CaO). For an average grade coal, 14.4 tons/hr of lime will be required during full load operation of the plant. Using the maximum sulfur content coal (1 percent sulfur), 26.4 tons/hr of lime will be used during full load operation.

One slaker will be provided for each SO2 emission control system on the plant's four units and a spare slaker will be provided for each pair of units. The spare slaker will ensure a reliable supply of lime to the scrubbers and allow for periodic maintenance and cleaning of the slakers. The slakers will also be capable of supplying lime to the plant's water softening system and, thereby, eliminate the need for a spare slaker in the water softening system.

The slaker will produce hydrated lime as a 60 percent slurry, by chemical reaction of quicklime with water. Each slaker will be designed to provide 7.9 tons/hr of hydrated lime, sufficient to meet the requirements of the SO2 emission control system on each boiler. Water provided to the slakers will be of good quality in order to minimize maintenance and downtime, and will be supplied from the plant's raw water storage tanks. The resulting hydrated lime slurry will be pumped to a lime slurry feed tank. A spare slurry pump will be provided for reliability. The employment of a high solids lime slurry will prevent rapid settling during transient conditions of the SO2 emission control system.

The lime slurry feed tank will provide for diluting the lime slurry to 25 percent solids prior to pumping to the individual slurry reactor tanks. Additionally, it will provide storage for a minimum of 8.5 hrs of slaked lime to the scrubber modules.

Lime feed rates will be controlled by the pH of the slurry in the slurry reactors.

10.2.3 WASTES HANDLING SUBSYSTEM

The spent lime slurries from the SO2 scrubber modules will be gravity fed to the slurry reactor where adequate retention time will be provided for completion of chemical reactions between the lime and SO2. Fresh lime slurry makeup is fed to this slurry reactor along with the necessary makeup water to keep the slurry in the reactor tank at about 10 percent solids content. The spent scrubber slurry entering the reactor tank will lower the pH while the lime slurry makeup will raise the pH. The resulting increase in pH of the spent scrubber slurry coupled with the residence time in the reactor tank will allow sulfites and sulfates to crystallize out of solution. This precipitate, along with excess lime and fly ash collected by the scrubber, will be removed from the slurry reactor tank by a purge stream and pumped to a thickener.

A slurry reactor tank will be provided for each scrubber module. Agitators will be provided in each tank to keep solids in suspension and to ensure complete dispersion of makeup lime in the reactors. Spare pumps will be provided for removing the wastes from the slurry reactors to the thickener.

The function of thickener is to settle and dewater the waste sludge. The thickener will be sized to accommodate purge streams from all five slurry reactors in each SO2 emission control system. Spare pumps will be provided for pumping both thickener overflow and underflow streams. Clarified liquor overflow from the thickener will be pumped for reuse to a recycle hold tank which supplies makeup water to the SO2 emission control system. Thickener underflow is expected to nominally contain about 40 percent solids, although variations between 30 and 60 percent solids may occur. These variations are a function of thickener operation and the sulfur content of the coal. Since the sulfur content of the coal will be 1 percent or less, most of the waste sludge will be in the form of calcium sulfate.

Thickener underflow will be pumped to vacuum filters for further dewatering of the sludge to 60 percent solids. The amount of thickener underflow which is fed to the filters will be dependent upon the ability of the thickener to concentrate the solids. It is expected under certain operating conditions that the thickener underflow will be sufficiently concentrated to allow complete bypassing of the filters. Under these conditions, thickener underflow will be fed directly to a holding silo for mixing with fly ash and final disposal.

Normally it is expected that some of the thickener waste sludge will be processed through the vacuum filters. To ensure a continuous 60 percent solids sludge, two vacuum filters and one spare will be provided for each SO2 control system. Filtrate from the filters will be pumped to the recycle hold tank for reuse in the system. The resulting sludge will be gravity fed to a holding silo for mixing with fly ash and final disposal.

It is expected that some sodium and magnesium solubles will be in the filtered sludge. These solubles will be of benefit to the scrubbers by improving SO2 removal efficiencies and reducing potential scaling problems. Furthermore, it is environmentally desirable to reduce the amounts of these solubles contained in the wastes for disposal. To reduce these solubles, filter cake washing will be employed. The resulting wash water will be returned to the recycle hold tank for reuse in the SO2 control system.

The final waste sludge will contain approximately 60 percent solids. The solids will mostly consist of calcium sulfate with small amounts of magnesium sulfate, sodium sulfate, sodium chloride, calcium carbonate, fly ash, and inert material from the lime. Using worst grade coal at full load conditions, a maximum of 134 tons/hr of waste sludge will be produced by the entire plant's sulfur dioxide control system. The expected average weekly production will be 9580 tons.

10.2.4 MAKEUP WATER SUPPLY

The makeup water supplied to various operations of the SO2 emission control system will be designed to enhance the overall reliability of the system while reducing the amount of water consumed. The SO2 control system will primarily be designed to utilize plant wastewater, thus reducing raw water requirements.

Approximately 93 percent of the water required by the system is for saturation of the flue gas. Since water quality for saturation will not have a significant effect on reliability, the water provided will be composed of cooling tower blowdown and reclaimed process water from the scrubber system. This will be the poorest quality water used in the system with an expected dissolved solids concentration of about 80,000 ppm.

The most critical operation with regard to the quality of water used is the lime slaking process. To ensure reliable operation of this process, plant raw water will be used. Raw water will be supplied directly from the industrial water system.

Once the lime is slaked to provide a 60 percent solids slurry, cooling tower blowdown will be used to dilute the lime slurry to 25 percent solids content for use in the scrubbers. Cooling tower blowdown will also be used to wash the demisters and the filter cake produced by the vacuum filters as well as supply water to pump seals.

To provide a closed loop system and utilize the recovered process water, a recycle hold tank will be provided. This tank receives recovered water from the thickener, the vacuum filters, and the demister wash system. The tank provides water for saturating the flue gas and makeup to the slurry reactors. To complete the water balance, cooling tower blowdown is added to the tank. This 30,000-gal tank will provide about a 20-minute supply of water to the control system.

Cooling tower blowdown will be supplied from a single 250,000-gal tank. This tank will supply water to the control systems of all four units as well as water for handling boiler bottom ash.

10.3 NITROGEN OXIDES CONTROL

Applicable federal regulations stipulate that emissions of NOx discharged into the atmosphere by each auxiliary boiler and main steam generator shall not exceed 0.30 lb/million Btu heat input when fuel oil is burned, and 0.70 lb/million Btu heat input when coal is burned. Furthermore, use of the best practicable technology to control NOx emissions is required by the State of Utah.

NOx formation occurs in the combustion zone of the boiler resulting from thermal fixation of atmospheric nitrogen and conversion of fuel-bound nitrogen. Combustion modification techniques provide effective means of NOx emission control by lowering the peak flame temperature and minimizing oxygen availability for combustion.

Specific combustion techniques which could be employed to control NOx emission include off-stoichiometric firing, flue gas recirculation, overfire air ports, increased furnace area, tangential firing, and dual air register burners (Ref 7). The specific techniques which would be most effective in controlling NOx emissions depends upon the general boiler design. Such general boiler design is specific to each particular boiler manufacturer. Thus, the combustion techniques or combinations thereof will be evaluated and selected for the most effective control of NOx emissions for the specific boiler selected.

Combustion techniques will be selected to ensure that both auxiliary boilers and main steam generators meet applicable state and Federal regulations. All leading boiler manufacturers have demonstrated the ability to comply with all NOx regulations applicable to IPP.

10.4 SUPPLEMENTARY CONTROL SYSTEM

To ensure that ambient air quality standards will not be exceeded, a supplementary control system will be provided. The supplementary control system will consist of facilities for monitoring and predicting ambient SO2 concentrations, and 750-ft high stacks will be used to enhance plume dispersion and dilution. This system will serve as a backup to the SO2 emission control system and will provide for adjustments in plant operation should very severe meteorological conditions occur.

The system will provide a 24-hr warning of potential air quality problems while collecting data that indicates the plant's effect on air quality. Warnings will be determined by combining meteorological and plant emission forecasts with a valid air quality prediction model.

Meteorological forecasting will utilize the presently installed meteorological tower to provide wind speed and direction, thermal structure of atmosphere, and atmospheric stability. Emission forecasts will also be made, based on the actual sulfur content of the coal being burned and the projected plant load.

The meteorological and emission forecasts will be utilized in an air quality model to calculate expected future concentrations of SO2 in the plant vicinity. Since SO2 ambient air quality standards are the most difficult for this plant to meet, satisfying the SO2 standards will ensure that NOx and particulate ambient air quality standards will also be satisfied.

Plant operating strategy will be determined for maintaining air quality within standards. This strategy may include load reduction, fuel switching, or other changes in plant operation which would prevent possible violations of air quality standards.

To ascertain the accuracy of air quality predictions, six continuous ambient SO2 monitoring stations will be located near the plant. Special attention will be given to locating the monitoring stations at critical terrain points showing a potential for high SO2 concentrations.

Information from the SO2 monitoring stations, the meteorological tower, and the plant emission and load monitors will be telemetered at frequent intervals to a central station at the plant for printout and storage.

SECTION 11.0

LIME SUPPLY AND HANDLING SYSTEM

A high calcium pebble lime (based on 90 percent available CaO) will be used for removing SO2 from the flue gases and for raw water softening. Quantities of lime which will be required at an average (75 percent) load factor when all generating units are burning average grade coal, and a maximum continuous requirement for both average and minimum grade coals are shown in Table 11-1.

TABLE 11-1

LIME REQUIREMENTS
(tons/day)

	Lime Required for Removing SO2	Lime Required for Water Treatment	Total Lime Required
For average grade coal and 75% load factor	260	26	286
For average grade coal and maximum continuous rating	347	35	382
For minimum grade coal and maximum continuous rating	632	35	667

Note: Average and minimum grade coals are defined in Section 10.0, Table 10-2.

It is expected that the average lime requirement will be 2000 tons/week.

Lime will be purchased from an outside supplier and transported by rail or truck to the plant site. For transporting lime by truck, approximately 16 truck deliveries per day will be required, using 25-ton vehicles and a 5-day per week delivery schedule. Approximately 22 railroad cars per week will supply the plant's lime requirements. The Flintkote Company, U.S. Lime Division, located 45 miles west of Salt Lake City near the town of Grantsville, Utah has assured IPP that they will be able to supply the plant's needs from their existing facilities (Ref 1). Limestone will be mined and processed into high calcium pebble lime at Flintkote's facilities. If the Castle Valley Railroad is constructed and connected with the IPP coal haul railroad, deliveries of lime will be by railroad. If the IPP coal haul railroad is not connected with a main line railroad, the lime will be trucked to the plant site via Highway I-15 and U.S. Highway 50 to Green River and Highway U-24 to the plant site.

Typical chemical analysis of Utah lime to be supplied to the plant is shown in Table 11-2.

TABLE 11-2

CHEMICAL ANALYSIS OF UTAH LIME

	Percent by Weight
Calcium oxide, CaO	92.0
Calcium hydroxide, $Ca(OH)_2$	1.0
Magnesium oxide, MgO	2.5
Calcium carbonate, $CaCO_3$	1.0
Aluminum oxide, Al_2O_3	0.5
Iron oxide, Fe_2O_3	0.3
Others	2.7
	100.0

One lime receiving and unloading system will be used to supply the entire need of the plant. Unloading from truck or rail car to the lime storage bunker (Figure B1) will be accomplished by a pneumatic system. Advantages of a pneumatic system in lieu of a bottom dump and mechanical conveyor are virtually dustless unloading, a minimum of operator assistance, and reduced maintenance costs.

The storage bunker will be sized to hold 13,000 tons of lime which will provide 35 days of lime supply for the entire plant. The storage bunker will be located to accommodate either truck or rail delivery of lime while minimizing the distance to both the water treatment system and the SO2 scrubbers.

Lime from the plant storage bunker will be transported by means of pneumatic conveyors to the water treatment storage bin and to day tanks located near the lime slakers for the SO2 control systems. A total of four day tanks will be provided, one for each operating lime slaker of the four SO2 control systems. Each day tank, sized to hold 87 tons of lime, will supply 24 hrs of lime to the SO2 scrubber system it serves, assuming full load operation and average grade coal.

Precipitate from the water softening system will consist of limestone and magnesium hydroxide. This sludge will be utilized to the extent possible to supplement the lime supplied to the SO2 scrubber systems. Since the degree to which this waste sludge can be utilized by the SO2 scrubbers is unknown, the lime supply system will be designed as if no supplement were available.

SECTION 12.0

ASH HANDLING SYSTEMS

The ash handling systems will remove the bottom and economizer ash from the boiler, the mill pyrites from the coal pulverizers, and the fly ash from the electrostatic precipitator hoppers and transport these materials to holding containers for storage and preparation for truck disposal.

Three separate systems will be used. One will be for the removal of the bottom ash, economizer ash, and mill pyrites from the boiler; another will be for the removal of fly ash from the electrostatic precipitator; and the third will be for mixing fly ash and scrubber sludge for disposal.

The systems are based on the following assumptions:

1. Maximum coal consumption of one boiler unit at full load will be 400 tons/hr.
2. Maximum ash content of the coal will be 12 percent.
3. Maximum production of bottom ash and economizer ash will be 31 percent of the total ash production.
4. Maximum amount of fly ash collected in the electrostatic precipitator will be 83 percent of the total ash production.
5. Mill pyrites will be as much as 0.4 percent of the coal consumption.
6. Trucks will be used to haul the ash, scrubber sludge, and mill pyrites to the disposal site.

12.1 BOTTOM AND ECONOMIZER ASH HANDLING SYSTEM

The bottom and economizer ash handling system, shown in Figure B22, is typical for one boiler unit. It includes all the equipment, piping and controls between the economizer hoppers, bottom ash hoppers, mill pyrites storage hoppers, and the dewatering tanks. Water will be used as the cooling and transporting medium for the system.

The system will collect and transport to the dewatering tanks ash collected at the bottom of the boiler (bottom ash), ash collected in the economizer hoppers (economizer ash), and material rejected by the coal pulverizers (mill pyrites).

The expected maximum production rate of ash and mill pyrites will be 16-1/2 tons/hr per boiler of which 10 tons/hr will be bottom ash, 5 tons/hr will be economizer ash, and 1.5 tons/hr will be mill pyrites. The system will transport ash and mill pyrites slurries to the dewatering tanks at a maximum rate of 80 tons/hr so that the ash and pyrites transfer hoppers can be emptied once each 8-hr work shift.

The system will be a closed system with no blowdown. Makeup water to the system will provide for water lost by evaporation and moisture absorbed in disposed ash.

12.1.1 BOTTOM ASH

The bottom ash will fall directly into the water impounded in the bottom ash hopper, where large lumps of ash will shatter into smaller pieces by the quenching action of the colder water. To unload the ash from the hoppers, the ash and water will be fed to crushers to further reduce the size of the ash particles so that it can be pumped as a slurry. Water will be supplied to the hopper agitators to aid in the removal of settled ash particles. From the ash crushers, the ash slurry will be pumped to the ash transfer tank by three sequentially operated jet pumps each with a capacity of 2700 gpm (80 tons/hr of ash). The slurry will then be pumped to the dewatering tanks by a 2700 gpm slurry pump. At the end of each pumping operation, water will be added to the ash transfer tank to flush the pumps and the pipelines.

12.1.2 ECONOMIZER ASH

The economizer ash will flow continuously into respective economizer ash hoppers where water will be added to produce a pumpable slurry. This slurry will be fed to water jet pumps for delivery to the dewatering tanks.

12.1.3 MILL PYRITES

The removal of mill pyrites from the mill pyrites storage hoppers will be an intermittent operation initiated manually by plant personnel.

The mill pyrites in the mill pyrites storage hoppers will be transported in slurry form to the pyrites transfer hopper by water jet pumps. From this hopper, the slurry will be transported to the dewatering tanks, once every 8-hr work shift, by a water jet pump.

12.1.4 DEWATERING TANKS

Two dewatering tanks will be provided in the system. This will allow alternate unloading of the tanks for truck disposal.

The dewatering tanks will permit the solids in the ash and mill pyrites slurries to settle and make the settled material suitable for truck disposal. The decanted water from this tank will overflow into the settling tank.

12.1.5 WATER SUPPLY AND STORAGE

Decanted water from the dewatering tanks will flow to the settling tank to allow finer ash particles still in suspension to settle. The overflow from the settling tank and makeup water will be supplied to the surge tank which will be the water storage tank for the system. This tank will be sized to assure a reliable water supply for the ash and mill pyrites transport systems. The settled ash in the settling tank and surge tank will be pumped to the dewatering tanks.

A full-sized standby pump will be connected in parallel with each pump (except jet pumps), as shown in Figure B22. This will allow backup availability and normal pump maintenance while the system is in operation.

12.1.6 ASH PIT SUMPS

Two ash pit sumps will be included in the system. The boiler ash pit sump will collect the overflows from the bottom ash hoppers and the ash transfer tank. The loading station ash pit sump will collect the water used to wash down the ash loading station area. The contents of these sumps will be pumped to the dewatering tanks by sump pumps.

12.2 FLY ASH HANDLING SYSTEM

The fly ash handling system shown in Figure B21 is typical for one boiler unit. It includes all the equipment, piping, and controls between the electrostatic precipitator ash feeders and the fly ash silo. Air will be used as the transporting medium for the system.

The system will collect an expected maximum of 40 tons/hr of fly ash from the electrostatic precipitator ash hoppers and transport the fly ash to the silo at a rate of about 88 tons/hr so that the ash hoppers can be emptied periodically each 8-hr work shift.

12.2.1 CONVEYOR AIR

Three half-capacity transport blowers each rated 2400 cfm at 12 psig will provide the air required to convey the ash to the fly ash silo. The air used to convey the ash to the silo will be returned to the electrostatic precipitator by a silo vent fan rated at 10,000 acfm at 12 in. water gauge to prevent the emission of fly ash to the atmosphere.

12.2.2 CONVEYOR FLOW ARRANGEMENT

The conveyor flow arrangement shown in Figure B21 is representative of a typical electrostatic precipitator system. The number and arrangement of feeders will be determined after the electrostatic precipitator contract has been awarded.

12.2.3 FLY ASH CONVEYING

The ash from the electrostatic precipitator ash hoppers will be conveyed to the fly ash silo by feeding the ash from one ash hopper at a time to the conveyor line until all ash hoppers are emptied. This is necessary to prevent plugging of conveyor lines.

The ash feeder shown in detail A of Figure B21 is one ash feeder design. Other feeder designs will be considered during final design.

12.2.4 FLY ASH SILO

The fly ash silo will have a storage capacity of about 46,000 cu ft. This will provide sufficient storage capacity for 2 or more days of ash produced at the maximum expected rate of 40 tons/hr per boiler.

To allow for backup storage capacity, fly ash piping cross connection to the fly ash silo of another boiler unit will be provided.

12.3 FLY ASH AND SCRUBBER SLUDGE MIXING SYSTEM

The fly ash and scrubber sludge mixing system shown in Figure B23 is typical for one boiler unit. It includes all equipment, piping and controls between the fly ash silo outlet, the scrubber sludge holding silo, and the pug mills.

The system will mix the ash from the fly ash silo with sludge from the scrubber sludge holding silo to produce a mixture suitable for truck disposal. Water from the scrubber water storage tank will be used to wet the fly ash in the event scrubber sludge is not available in sufficient quantity.

The correct proportion of ash and sludge required to form a truckable mixture will be determined during the initial operation of the plant.

It is expected that there will be a maximum production rate of 41 tons/hr of sludge from one SO2 scrubber and of 40 tons/hr of fly ash from one electrostatic precipitator.

SECTION 13.0

TURBINE GENERATOR

A study was made to determine the optimum turbine throttle conditions for the plant (Ref 1). The following two conditions were compared in the study:

1. Subcritical (2400 psig, 1000F/1000F), drum type boiler
2. Supercritical (3500 psig, 1000F/1000F), once-through type boiler

An economic comparison of the two conditions indicated that the subcritical turbine throttle condition would be the most economical. In addition, a survey of the electric utility industry indicated that an increasing number of large coal-fired subcritical units have been purchased.

The turbine-generator heat cycle diagram, as shown in Figure B17, and the turbine-generator heat balance diagram, as shown in Figure B18, form the basis for the equipment selection and systems described in Sections 13.0 through 20.0.

The turbine generator for each unit will have a guaranteed capability of 820,000 kw. Each turbine-generator unit will be a single reheat, tandem-compound, 3600 rpm, condensing, extraction type.

The turbine will consist of four turbine sections connected in tandem: one high pressure section receiving steam from the boiler superheater, one intermediate pressure double flow section receiving steam from the boiler reheater, and two low pressure double flow sections receiving steam from the intermediate pressure section and exhausting into the main condenser.

The turbine generator will be housed in the Turbine-Generator Building. An enclosure will be furnished for the high pressure and intermediate pressure turbine sections to reduce noise.

13.1 NET PLANT HEAT RATE

The net heat rate of the plant at any time will be dependent upon the amount of auxiliary power being used within the plant at the time, turbine backpressure, percent plant loading, and other factors. The net heat rate for the plant, at full load, is estimated to be 9990 Btu/kwh. This net heat rate does not include the energy required for the operation of the surface and underground water pumps.

13.2 TURBINE DESIGN CONDITIONS

The turbine-generator manufacturer will be required to guarantee that the unit will deliver 820,000 kw based on the following conditions:

1. Extracting steam for feedwater heating.
2. Extracting steam for boiler feed pumps and induced draft fan turbines.
3. Extracting steam for air preheating and stack gas reheating.
4. A condenser multi-backpressure of 2.85 and 1.84 in. HgA.
5. Turbine throttle pressure of 2400 psig.
6. Turbine throttle temperature of 1000F.
7. Reheat steam temperature of 1000F.
8. Feedwater cycle water makeup of 1 percent to replace normal boiler blowdown and other losses.

The turbine will operate safely at 105 percent of rated pressure with valves wide open. Under these conditions the expected maximum capability will be approximately 884,000 kw.

13.3 TURBINE GLAND SEAL SYSTEM

Steam seals will be provided on all turbine glands to prevent leakage of steam into the atmosphere or air leakage into the turbine along the shaft of the turbine. A small condenser will be provided to condense all the steam leaving the glands that is not returned to the turbine or to extraction piping.

13.4 LUBRICATION SYSTEM

A complete oiling system will be provided, including oil pumps, duplicate oil coolers, and an oil reservoir. The main turbine oil pump will be driven by the turbine or generator rotor. In addition the following oil pumps will be provided:

1. An a-c motor driven auxiliary oil pump.
2. An a-c motor driven bearing and turning gear oil pump.
3. A d-c motor driven oil pump which will be used as an emergency backup for the bearing and turning gear pump.

13.5 LUBE OIL PURIFICATION SYSTEM

A separate lube oil purification system for the main turbine-generator lubrication system will be provided. It will maintain the design purity of the lube oil and provide a means to fill and empty the lube oil reservoir.

13.6 TURBINE CONTROL SYSTEM

Two turbine-generator units will be controlled and supervised from a centralized control room. An electric control system with solid state circuitry will be provided to regulate the speed and loading of the turbine and to initiate action to protect the turbine during abnormal operating conditions. The speed/load controls will perform in accordance with the ASME - IEEE Recommended Specifications for Speed Governing of Steam Turbines.

The following turbine-generator auxiliary equipment will be controlled from the control room:

1. Drain valves for turbine start-up and shutdown.
2. Motor-driven lubricating oil pumps.
3. Turning gear.
4. Lube oil vapor extractor.
5. Gland steam exhauster.
6. Control fluid pumps.
7. Control fluid vapor extractor.

13.7 TURBINE-GENERATOR SUPERVISORY INSTRUMENTATION

Control room instrumentation will include a high speed events recorder and visual annunciation system that will monitor all alarm contacts.

Instrument connections will be provided as required for an ASME acceptance test.

Monitoring of the following will be provided:

1. Turbine exhaust hood temperature
2. Bearing temperatures
3. Lube oil pressures
4. Lube oil temperatures
5. Lube oil reservoir level
6. Turbine metal temperatures
7. Water induction into the turbine
8. Control fluid pressures
9. Control fluid temperatures
10. Control fluid reservoir level
11. Turbine valve positions

13.8 GENERATOR

The generator will have a continuous capability of 912 Mva at 0.9 lagging power factor. It will be a wye-connected, three-phase, 60-Hz machine with an expected terminal voltage of 24 to 26 kv. The short circuit ratio will be not less than 0.58.

A pole face amortisseur will be provided to minimize the negative resistance of the generator to subsynchronous armature currents.

13.9 GENERATOR COOLING SYSTEM

The generator cooling system will be a totally enclosed, recirculating system which will permit safe temperatures at the maximum rated capacity of the generator.

13.10 GENERATOR SHAFT SEALING SYSTEM

An oil sealing system will be provided to minimize shaft leakage of air or hydrogen.

13.11 EXCITATION SYSTEM

The excitation system will be capable of attaining 95 percent of the difference between ceiling voltage and rated field voltage in 0.1 second or less. An excitation voltage response ratio of 2.0 will be provided. The excitation system will be of the static or brushless alternator type.

The excitation system control will consist of a continuously acting voltage regulator with a minimum accuracy of plus or minus 0.005 percent. A volts-per-hertz limiter will be provided to prevent transformer overexcitation.

13.12 SUBSYNCHRONOUS TORSIONAL SHAFT OSCILLATIONS

If an a-c transmission system were to be used to transmit power from IPP to Southern California then equipment would be required at IPP to limit subsynchronous torsional shaft oscillations. Because a d-c transmission system has been selected, these oscillations will not occur and the equipment will not be required. A further discussion of this potential problem is in Volume III, Section 5.0.

SECTION 14.0

MAIN AND REHEAT STEAM SYSTEM

Superheated steam will be generated in the boiler and piped to the high pressure section of the turbine. The steam exhausting from the high pressure section, except for bleed steam to Feedwater Heater 7, will return to the boiler where it will be reheated and piped to the intermediate pressure section. The steam exhausting from the intermediate pressure section then will go to the two low pressure sections and, except for bleed steam, will exhaust to the main condensers. The boiler feed pump turbine will be supplied from the main steam supply for low loads or from Feedwater Heater 5 bleed steam for higher loads.

All steam systems are shown in Figure B26 and include the following systems: main steam system, cold reheat system, hot reheat system, and boiler feed pump turbine steam supply.

14.1 MAIN STEAM

Steam at 2475 psig and 1005F will flow from the boiler superheater outlet header through the main steam lines to the high pressure turbine control valves where it will be 2400 psig and 1000F. As required by the turbine manufacturer, cleanout connections will be provided at the low points upstream of the turbine stop valves, for the removal of foreign matter. Strainers will be provided by the turbine manufacturer in each of the control valves.

Desuperheaters will be provided between the initial and final superheater sections of the boiler for main steam temperature control. Water for the desuperheaters shall be furnished from boiler feed pump discharge.

14.2 COLD REHEAT

Exhaust steam from the high pressure section will return to the boiler for reheating through the cold reheat lines. Bleed steam for Feedwater Heater 7 will be taken from the cold reheat.

Spray desuperheaters are provided in each of the cold reheat lines for reheat steam temperature control. Spray water is to be furnished from an intermediate stage of the boiler feed pumps.

14.3 HOT REHEAT

Reheated steam at 1005F will be piped from the boiler reheater outlet header through the hot reheat lines to the intermediate pressure section intercept valves where its temperature will be 1000F. Strainers will be provided by the turbine manufacturer at the intercept valves.

14.4 BOILER FEED PUMP TURBINE STEAM SUPPLY

For low load operation, steam will be supplied from the main steam line to the boiler feed pump turbine high pressure inlet stop valve. Under normal operation, steam will be supplied to the low pressure inlet stop valve from Feedwater Heater 5 extraction steam, with a backup from the auxiliary steam. The boiler feed pump turbines will exhaust to the low pressure main condenser.

14.5 DRAINS

Drain lines will be provided from the low points in the main steam, reheat, and boiler feed pump piping and from various turbine drain points. Drain lines will have diaphragm operated valves for automatic and remote manual operation. Prior to start-up, all the drain valves will be opened. During the turbine warm-up period, all of these valves are closed but will be periodically opened to drain condensate out of the lines. The drains will be connected to the condenser as they will be used during start-up when the turbine is under a vacuum.

14.6 SAFETY AND RELIEF VALVES

Safety and relief valves will be provided as required by applicable codes and regulations.

SECTION 15.0

CONDENSATE AND FEEDWATER SYSTEM

The function of the condensate and feedwater system is to supply the steam generator with heated feedwater which has been deaerated and chemically treated to maintain a specific water quality. The major equipment in this system is the main steam condenser, seven feedwater heaters (Ref 1), condensate pumps, boiler feed booster pumps, and boiler feed pumps.

15.1 CONDENSATE SYSTEM

The condensate system shown in Figure B28 is the low pressure portion of the condensate and feedwater system, and will include all the equipment, piping, and controls between the main steam condenser and the deaerating heater, inclusive.

During normal operation, two of the three half-capacity condensate pumps will take suction from the condenser hotwell and will discharge condensate through the gland steam condenser and air ejector condensers connected in parallel. Then the condensate will flow into a common header before branching into two parallel half-capacity heater trains (Ref 2) and Low Pressure Heaters 1 and 2. There will be a motor operated valve before and after each train so that either train can be isolated while the unit is operating. Each train will be suitable for continuous operation carrying the combined flow during a forced outage of the other train. After the condensate leaves these two stages of feedwater heating, the combined flow will go through a single full-capacity Low Pressure Heater 3 before entering the Deaerating Heater 4. Heater 3 will be provided with a full flow bypass.

The arrangement of the condensate system components will provide for recirculation at low flows to maintain the required minimum flow through the condensate pumps, air ejector condensers, and gland steam condenser.

The system will also provide for condenser hotwell level control, condensate makeup or drawoff and storage, seal injection water for sealing pump glands, condensate for the turbine exhaust hood sprays, bearing cooling water system makeup, and condensate for the gland seal steam emergency desuperheater.

The condensate system will include an additional condenser which will service the induced draft fan turbine, steam air heater, and flue gas reheater.

15.1.1 CONDENSATE STORAGE TANKS

The condensate storage tanks for each unit will contain 1 million gal which is enough condensate to provide 1 percent makeup for approximately 5-1/2 days.

15.1.2 CONDENSATE TRANSFER PUMP

A condensate transfer pump will be provided for each unit to facilitate transfer of condensate between units. This pump will take suction from the condensate storage tanks and discharge into a common header for all the units.

15.1.3 MAIN STEAM CONDENSER

Each unit will have one main steam condenser which will be a single-shell, dual-pressure, single-pass, deaerating type of surface condenser with divided waterboxes and hotwell (Ref 3). It will condense and deaerate the exhaust steam from the main turbine and the boiler feed pump turbines prior to the condensate returning to the steam generator through the condensate and feedwater system. In addition, the condenser will serve as a heat sink for several other flows, such as air ejector condenser drains, gland steam condenser drain, low pressure feedwater heater vents and drains, main steam piping drains, induced draft fan condenser drains, and other miscellaneous flows, drains, and vents.

The main steam condenser will have an effective surface area of 382,000 sq ft using 24,000, 20-gage, 7/8-in OD, 90-10 copper-nickel tubes. The tube length will be 70 ft and the tubes will be designed for a water velocity of 6 fps. The hotwell storage will be sized to provide a minimum of 5 minutes of total storage at maximum condensate flow.

The discharge waterboxes will have automatic air removal valves.

An automatic hotwell level control system will be furnished to monitor the hotwell level and control the makeup and drawoff to maintain the hotwell level to within acceptable limits by automatically transferring condensate to and from the condensate storage tank.

15.1.4 AIR REMOVAL EQUIPMENT

Each main steam condenser will be provided with an evacuation system to remove noncondensable gases and air during plant start-up, cool down, and normal operation. Noncondensable gases and in-leaking air will be removed continuously to maintain minimum absolute back pressure in the condenser and to minimize concentration of corrosive gases in the condensate system.

The system will consist of a motor-driven vacuum pump to rapidly evacuate the air in the condenser when starting a unit and a twin element, two-stage steam jet air ejector to be used during normal operation. In addition, the motor-driven vacuum pump will serve as a standby for the steam jet air ejector.

Each element of the air ejector will be rated for 15 scfm of air saturated with vapor at a suction conditon of 1.0 in. HgA and 7.5F subcooling. At these same conditions the motor-driven vacuum pump will be rated for 35 scfm.

15.1.5 AIR EJECTOR CONDENSERS

Condensate will be the coolant used in the air ejector intercondenser and aftercondenser to condense the air-vapor mixture from the main condenser prior to discharge of the air to the atmosphere. Condensate will flow in parallel through the intercondenser and aftercondenser. The drain from the condensers will be returned to the main condenser hotwell.

15.1.6 CONDENSATE PUMPS

Three half-capacity, vertical, can type, direct motor-driven, condensate pumps will be provided to draw condensate from the condenser hotwell and pump it through Feedwater Heaters 1, 2, and 3 to Deaerating Heater 4. Each pump is rated at 4500 gpm at 580 ft total head. The speed of the four-stage pump will be 1750 rpm.

15.1.7 GLAND STEAM CONDENSER

Condensate will also be used to condense the steam exhausted from the turbine steam seal system in the gland steam condenser. The gland steam condenser will be connected in parallel with the air ejector condensers, and will be provided with a bypass line to permit the isolation of either or both the gland steam condenser and air ejector condensers. The condensed steam will be returned to the main condenser hotwell.

15.1.8 LOW PRESSURE FEEDWATER HEATERS 1, 2, AND 3

There will be three low pressure feedwater heaters between the condensate pumps and the deaerator heater. The first two heaters will be divided into two parallel half-capacity heaters, Heaters 1 and 2, and are located in the condenser necks. The third heater, Heater 3, will be located ahead of the Deaerator Heater 4.

The low pressure heaters will be horizontal, channel head bolted cover type with U-tube construction of admiralty tubes. Heaters 1, 2, and 3 will have an integral condensing and drain cooling section. Heaters 1 and 2 each will have heating surface areas of 8960 and 6730 sq ft, respectively, and Heater 3 will have 11,840 sq ft.

15.1.9 DEAERATING FEEDWATER HEATER 4

Deaerating Heater 4 will be of the horizontal spray, stainless steel tray type consisting of a deaerating section and a storage tank. Spray pipes will distribute the condensate for integral mixing with extraction steam in the deaerating section. The condensate will then cascade over trays for maximum surface contact with steam to effect removal of noncondensable gases.

This heater will deaerate incoming condensate to 0.005 cc/l or less of free oxygen, zero carbon dioxide, and will heat the condensate to a saturation temperature corresponding to the shell pressure.

The deaerator storage tank will be sized to store condensate equivalent to 5 minutes of the feedwater flow.

15.1.10 INDUCED DRAFT FAN TURBINE CONDENSER

One condenser will serve both induced draft fan turbines and will be of the single-shell, single pressure, two-pass divided water box deaerating type. This condenser will also serve the steam air heater and flue gas reheater prior to returning the condensate to the hotwell of the main steam condenser. It will have an effective surface area of approximately 30,000 sq ft using 3500, 20-gage, 7/8-in OD, 90-10 copper-nickel tubes. The tube length will be 37 ft.

The air removal equipment will consist of two motor-driven vacuum pumps. One will be used for holding the desired pressure during normal operations, and the other for hogging during start-up operations. In addition, a third pump will serve as a standby.

The condensate leaving the hotwell will be pumped to the hotwell of the main steam condenser by two of the three half-capacity induced draft fan condensate pumps.

15.2 FEEDWATER SYSTEM

The feedwater system shown in Figure B27 is the high pressure portion of the condensate and feedwater system, and it will include all the equipment, piping, and controls between the deaerating heater and the boiler.

Three half-capacity boiler feed booster pumps will provide sufficient NPSH for two 60 percent capacity boiler feed pumps. The booster pumps will draw from the elevated deaerating storage tank and will then discharge through a single stream (Ref 4) to full-capacity Intermediate Pressure Feedwater Heaters 5 and 6 to the boiler feed pumps. The feedwater from the boiler feed pumps will discharge through a full-capacity High Pressure Heater 7 before entering the steam generator economizer inlet header. Each of the intermediate and high pressure heaters will be provided with an individual full flow motor-operated bypass. Also, there will be double valves with a bleedoff between them on each side of the heaters so that the heaters can be isolated and maintained safely while the unit is in operation. The double valves are required because these heaters have manhole access rather than removable heads. One of the double valves will be motor operated.

Spray water for the cold reheat desuperheater will be bled from an intermediate stage of each of the boiler feed pumps, and spray water for the main steam desuperheater will be taken from the boiler feed pump discharge.

Each booster and boiler feed pump will be equipped with minimum flow controls and warm-up piping to maintain ready temperature for standby operation. Pump recirculation systems will discharge to the deaerator storage tank.

15.2.1 BOILER FEED BOOSTER PUMPS

The boiler feed booster pumps will take suction from the deaerating storage tank. These half-capacity boiler feed pumps are of the horizontal, motor-driven, single stage, double volute, double suction, centrifugal type. Each will have a capacity of approximately 6300 gpm at 1050 ft total head.

15.2.2 BOILER FEED PUMPS

The two boiler feed pumps will be 14 x 14 x 14 in., four-stage, horizontal, double case centrifugal pumps. The first stage will be double suction. The third and fourth stages will flow in opposite direction from the second stage. The forged outer barrel will be pressurized to the pump discharge pressure, which will act on the outside of the cast inner volute case and hold together the horizontal split between the two halves. The normal operating point (rated unit load) will be 6680 gpm at 6760 ft and 410F feedwater with a speed of approximately 5200 rpm. The efficiency will be 86.5 percent. The design point corresponding to valves-wide-open and 5 percent over-pressure main turbine throttle condition will be 7400 gpm discharge at 7280 ft and 420F feedwater with a speed of 5550 rpm. The input requirement is 13,600 BHP. An interstage take-off will be provided for attemperation of the reheat. The pumps will have controlled injection throttle bushing-type stuffing boxes. The first stage closest to the pumped water will have an injection of feedwater from the boiler feed booster pump discharge. The next stage will drawoff to the deaerator. The third stage will have an injection of condensate from the condensate pump discharge. The last two stages will drawoff to the condenser.

15.2.3 BOILER FEED PUMP TURBINES

Each boiler feed pump will be driven by a 13,600 hp, 5550 rpm, condensing steam turbine. Each turbine will have one high pressure and one low pressure steam stop/control valve. Piping and automatic controls will be provided for:

1. Admitting main steam to the high pressure steam stop/control valve (and auxiliary steam to the low pressure steam stop/control valve) on start-up.

2. Admitting main steam to the high pressure steam stop/control valve at main unit loads below 40 percent with two boiler feed pump turbines in service, and at main unit loads to 60 percent with one boiler feed pump turbine in service.

3. Admitting turbine crossover steam to the low pressure steam stop/control valve for main unit loads above 40 percent with two boiler feed pump turbines in service.

Each boiler feed pump turbine will exhaust to the main condenser.

The two boiler feed pump turbines will have individual self-contained lube oil systems, each with a lube oil reservoir, pumps, and two full-capacity oil coolers. Each system will supply the lube oil for its corresponding boiler feed pump. The two lube oil systems will share a single lube oil purification unit.

15.2.4 INTERMEDIATE PRESSURE FEEDWATER HEATERS 5 AND 6

There will be two full-flow intermediate pressure feedwater heaters between the booster and boiler feed pumps. Heaters 5 and 6 will be horizontal hemispherical head type with U-tube construction of 90-10 copper-nickel tubes. Both heaters will have integral desuperheating, subcooling, and condensing zones. Heaters 5 and 6 will have heating surfaces of 14,400 and 17,800 sq ft, respectively.

15.2.5 HIGH PRESSURE FEEDWATER HEATER 7

There will be one full-flow high pressure feedwater heater between the boiler feed pump and steam generator. Heater 7 will be a horizontal hemispherical head type with U-tube construction of 70-30 copper-nickel tubes. It will have a heating surface of 33,300 sq ft, and will have integral desuperheating, subcooling, and condensing zones.

SECTION 16.0

BLEED STEAM SYSTEM

To improve the cycle efficiency, bleed steam will be extracted from various sections of the turbine and supplied to the following equipment: the shell side of regenerative feedwater heaters, the tube side of the evaporator, the steam air heaters, the flue gas reheaters, and the turbines (for driving the boiler feed pumps and induced draft fans) as shown in Figure B29. Table 16-1 shows sources of bleed steam.

TABLE 16-1

BLEED STEAM SOURCES

Equipment	Steam Source
Feedwater Heaters 1-1 and 1-2	Low pressure section
Feedwater Heaters 2-1 and 2-2	Low pressure section
Feedwater Heater 3	Low pressure section
Deaerating Feedwater Heater 4	Low pressure section
Feedwater Heater 5	Intermediate pressure section
2 Boiler feed pump turbines	Intermediate pressure section
2 Induced draft fan turbines	Intermediate pressure section
Steam Air Heaters A1, A2, B1, & B2	Intermediate pressure section
Flue Gas Reheaters A, B, C, D, & E	Intermediate pressure section
Evaporator	Intermediate pressure section
Feedwater Heater 6	Intermediate pressure section
High Pressure Feedwater Heater 7	Cold reheat

16.1 LOW PRESSURE FEEDWATER HEATERS 1, 2, AND 3

Feedwater Heaters 1-1 and 1-2 will be located in the condenser neck below one of the low pressure turbines from which it receives bleed steam.

Feedwater Heaters 2-1 and 2-2 will also be located in one of the condenser necks above the feedwater heater and below a low pressure cylinder of the turbine from which it will receive its bleed steam.

Bleed steam for the single external Feedwater Heater 3 will be supplied by interconnected lines from the low pressure section of the turbine.

16.2 DEAERATING FEEDWATER HEATER 4

Bleed steam for Deaerating Feedwater Heater 4 will normally be supplied from each of the low pressure cylinders of the turbine. The pressure in the deaerating heater will be limited to a minimum of 5 psig. At low loads, the turbine pressure source may drop below 5 psig, and the steam for the deaerating heater will be automatically fed and regulated from the auxiliary steam system. The evaporator will discharge into the deaerating heater.

16.3 INTERMEDIATE FEEDWATER HEATERS 5 AND 6

Bleed steam for Feedwater Heater 5 will be supplied from the intermediate pressure section of the turbine. A motor-operated shutoff valve will be provided on the bleed line. The motor-operated valve will automatically close when the heater is being bypassed to prevent the tube side thermal relief valve from opening and to prevent flashing in the suction side of the boiler feed pump when the heater is put back in service.

Bleed steam for Feedwater Heater 6 will be supplied from the intermediate pressure section of the turbine. The bleed steam block valve will be closed when the heater is being bypassed to prevent the tube side thermal relief valve from opening.

16.4 HIGH PRESSURE FEEDWATER HEATER 7

Bleed steam for Feedwater Heater 7 will be supplied from the cold reheat steam line. The bleed steam block valve will be closed when the heater is being bypassed to prevent the tube side thermal relief valve from opening.

16.5 EVAPORATOR

The evaporator will supply distilled makeup water of quality suitable for use in the feedwater cycle. Bleed steam for the evaporator will be supplied from Feedwater Heater 5 extraction line through a nonreturn valve and a bleed steam block valve. The condensate drains to Heater 5 flash tank. The incoming treated water will be heated in the evaporator blowdown heat exchanger by the evaporator blowdown and then further heated in the evaporator deaerator. The generated steam will be exhausted to Deaerating Heater 4 (Ref 1).

16.6 BOILER FEED PUMP TURBINES

Bleed steam for the boiler feed pump turbines will be supplied to the low pressure inlet stop valve from Feedwater Heater 5 extraction line with a backup from the auxiliary steam, and will exhaust to the low pressure compartment of the main condenser. For low load operation, steam will be supplied from the main steam line to the high pressure inlet stop valve.

16.7 INDUCED DRAFT FAN TURBINES

Bleed steam for induced draft fan turbines will be supplied from Feedwater Heater 5 extraction line. The line to each turbine will have a supply of auxiliary steam to a separate turbine inlet for operation during start-up. The turbines will exhaust to the induced draft fan turbine condenser. Drains to the condenser will be provided at all low points in the steam lines.

16.8 STEAM AIR HEATERS

Bleed steam for the steam air heaters will also be supplied from Feedwater Heater 5 extraction line. These air heaters keep the combustion air from going below a minimum temperature to prevent condensation and corrosion in the main air heater. The condensate will drain to the induced draft fan turbine condenser in addition to the drains from low points in the line. Vents will go to the blow-off tank.

16.9 STEAM STACK GAS REHEATERS

Bleed steam for the steam stack gas reheaters will also be supplied from Feedwater Heater 5 extraction line. These gas reheaters keep the flue gas from going below a minimum temperature of 170F to prevent condensation and corrosion in the ducts and stack. The condensate will go to the induced draft fan turbine condenser along with the drains from the low points in the lines. The vents will go to the blow-off tank.

16.10 RELIEF VALVES

Safety relief valves will be provided on the intermediate and high pressure heaters to protect the heater shells from overpressure in the event of a tube rupture.

16.11 NONRETURN VALVES

Nonreturn valves will be installed in the bleed steam lines as recommended by turbine equipment manufacturers. These valves protect the turbine from overspeed on load rejection and from the possibility of thermal shock caused by backflow from tube ruptures in the heaters. The bleed line to Deaerating Heater 4 will have two nonreturn valves in series to provide double protection because of the large amount of energy stored in this heater and its storage tank. Nonreturn valves will not be provided in the bleed lines to Heaters 1 and 2 as the energy stored in these lines is too low to contribute materially to overspeed of the turbine during load rejection, and also, there will be no thermal shock hazard present since in case of a tube leak, the high level in the heater will automatically close the water side valves and reduced load will be carried on the other heater.

All nonreturn valves will close whenever the turbine trips due to overspeed. High water level in a heater will close only the nonreturn valves in the line supplying steam to that heater.

16.12 BLEED STEAM DRAINS

Drains will be provided at the low points in all external bleed lines for use during start-up and shutdowns. The drains from the heater side of the shutoff valves will discharge to waste through hand valves. The drains from the turbine side of the shutoff valves will discharge to the condenser through control valves which open when the nonreturn valves close. During normal operation of the unit, the bleed lines will be hot and the drain valves will be closed.

Steam traps will be provided at the low points of the bleed steam lines to the boiler feed pumps which will not be in service at all loads. Steam traps will also be provided in the low points of the lines to the induced draft fan turbines, steam air heaters, and steam stack gas reheaters.

SECTION 17.0

HEATER VENTS AND DRAINS SYSTEM

The heater vents and drains system shown in Figure B31 will provide for cascading the feedwater heater condensed extraction steam (drains), venting the feedwater heaters and gland steam condenser, and for draining the gland steam condenser.

17.1 HIGH AND INTERMEDIATE PRESSURE HEATER SYSTEM

In Feedwater Heaters 5, 6, and 7, the extraction steam will be condensed on the tubes and collected in the bottom of the horizontal shell. The drains will then pass through integral drain coolers where it will be cooled to within 10F of the incoming boiler feedwater temperature.

Heater 7 will drain in series to Heater 6, Heater 5, and a flash tank normally having the same pressure as the deaerator. It is not practical to permit the drains from Heater 5 to go directly to the deaerator since flashing would take place in the line.

The water level in each high pressure feedwater heater will be controlled by means of a level controller and control valve system that throttles the drains to the next lower heater.

Heaters 5, 6, and 7 will have a second level controller which transmits a signal to indicate the water level in the heater. The signal will actuate four pressure switches to operate a low level alarm, a high level alarm, a high level bypass switch, and a high level trip which will close the turbine nonreturn valves in the event of a flooded heater.

The Heater 7 drain line will be provided with a drain connection directly to the Heater 5 flash tank in case of excessive flow to Heater 6. The Heater 6 drain line will be provided with a bypass line to the Heater 5 flash tank for use when Heater 5 is not in service. The Heater 5 drain line will be provided with a bypass line connected directly to the high pressure zone of the main condenser for use during start-up, the period of high contamination.

Each high pressure feedwater heater will be vented to the Heater 5 flash tank. Each shell vent connection will be furnished with an orifice designed to provide proper venting. Stop valves will be provided in the vent lines to isolate each heater. Vent lines will be used to remove air or noncondensible gases which accumulate in the feedwater heaters. Vent piping downstream of the orifices will be stainless steel for erosion, as well as corrosion protection.

Manual drain cooler bypass valves will be installed on Heaters 5, 6, and 7 to facilitate level control during start-up and to enable complete draining of heater shells for maintenance.

17.2 HEATER 5 FLASH TANK AND DRAIN PUMPS

All drains will impinge upon a stainless steel plate. The steam will be separated from the water by means of baffles, and will flow to the deaerator through the balance line.

The level in the Heater 5 flash tank will be regulated by means of two controllers. One controller will be used for transmitting high level and low level alarms to the control rooms and automatic start of the standby drain pump. The other controller will be used to regulate the control valve at the discharge of the two Heater 5 drain pumps.

The Heater 5 flash tank drain pumps will be operated by OFF-STANDBY-RUN selector switches in the control room. For normal operation, one of the drain pumps will be selected to run continuously until manually de-energized. The second pump will be on STANDBY and will be energized by the level control system of the flash tank. The starting of the standby pump will indicate malfunctioning of the first pump or excessive drain flow, and an alarm "High Level Flash Tank" will be actuated. The standby pump will continue to operate until stopped manually with the selector.

Each heater drain pump will have a recirculation line for a minimum flow of 200 gpm for cooling purposes. The Heater 5 drain pumps will discharge into the deaerator for removal of noncondensable gases.

17.3 LOW PRESSURE FEEDWATER HEATERS

Heater 3 will be a single horizontal feedwater heater. Heaters 1 and 2 will each be composed of two, full flow horizontal heaters connected in parallel. All the heaters will be furnished with integral drain coolers.

During normal operation, the drains from Heater 3 will be split and cascaded into Feedwater Heaters 2-1 and 2-2; the drains from Heaters 2-1 and 2-2 will be cascaded into Heaters 1-1 and 1-2, respectively; and the drains from Heaters 1-1 and 1-2 will flow by gravity to the main condenser. Heaters 2 and 3 will have separate shell bypass connections to the main condenser and will be provided with automatically operated control valves to be used in the event of malfunction in the drain system and to drain heater shells for servicing.

Heaters 1, 2, and 3 will have two level control devices, one to control the level in the heater and the other to serve as a transmitter to indicate the high level and low level alarms. The level controller on Heater 3 will operate the control valves at the drain inlets to Heaters 2-1 and 2-2. The level controller on Heaters 2-1 and 2-2 will operate the control valve at the drain inlets to Heaters 1-1 and 1-2, respectively. The level controllers on Heaters 1-1 and 1-2 will operate the two control valves at the drain inlets to the condenser.

Each low pressure feedwater heater will have its own independent venting system which vents the noncondensable gases to the main condenser through fixed orifices located at each of the heater shell vent connections. Stop valves will be provided in vent lines to isolate each heater.

17.4 GLAND STEAM CONDENSER

The gland steam condenser will be located in the condensate system and will be used to condense steam and remove air from the turbine glands. The gland steam condenser will drain to the main condenser through a control valve. An overflow alarm will be provided to indicate faulty operation.

The noncondensable gases and air collected in the gland steam condenser will be removed by means of two centrifugal fans. The fans can be independently started from the control room. The gases exhausted by the fans will be vented into the atmosphere.

SECTION 18.0

CIRCULATING WATER SYSTEM

The purpose of the circulating water system, shown in Figure B32, is to transfer the heat rejected by the main condensers, the induced draft fan turbine condensers, and the cooling water heat exchangers to the atmosphere.

A study was made to evaluate various cooling water systems with respect to engineering, economic, and environmental factors. The following cooling water systems were studied:

1. Dry cooling towers.
2. Rectangular mechanical draft-wet-dry cooling towers.
3. Natural draft wet cooling towers.
4. Round mechanical draft wet cooling towers.
5. Rectangular mechanical draft wet cooling towers.
6. Spray ponds.
7. Cooling ponds.
8. Once-through cooling water.

The results of this study indicate that rectangular mechanical draft wet cooling towers will be the most suitable for use in the plant.

Two separate, parallel systems for each unit will provide maximum reliability and economy. Each system will include one cooling tower, one circulating water pump, a piping system, one side of the main condenser, one side of the induced draft fan turbine condenser, and one cooling water heat exchanger.

18.1 COOLING TOWERS

Each unit will be provided with two, 10-cell, mechanically induced draft wet cooling towers. These towers will be complete with gear drives and motors for the propeller fans; all necessary walkways and stairways; and manually regulated water distribution systems.

Each cooling tower will be designed for 133,500 gpm circulating water flow, 114F inlet, and 84F outlet water temperatures. The design wet bulb temperature will be 66F which will be exceeded only 5 percent of the time during the 4 summer months of a typical year. The difference between the cooling tower water outlet temperature and the atmospheric wet bulb temperature will be 18F at design conditions. The cooling towers will reject heat at the rate of 4 billion Btu/hr under design conditions (Ref 1).

18.2 CIRCULATING WATER PUMPS

Each circulating water pump will deliver 133,500 gpm at 64.4 ft TDH. The direct driving induction motor will be 3000 hp. The pumps will be operable at 20 percent of design flow to facilitate initial fill and start-up of the system. The pump discharge motor operated butterfly valve will be manually throttled to control this low starting flow and also will automatically keep the system full when the pump is stopped.

18.3 COOLING WATER HEAT EXCHANGERS

Two single-pass, full-size heat exchangers will be provided for each unit, each containing 2300, 20-gage tubes, 3/4-in. OD and 48 ft long. The tube material will be 90-10 copper-nickel.

18.4 MAKEUP WATER

The makeup water will enter the cooling tower basin through a basin level control valve. The makeup water requirements for the cooling tower are discussed in Section 31.0; the circulating water treatment and quality control are discussed in Section 34.2.

18.5 COOLING TOWER BASIN DRAIN SYSTEM

The water level will first be lowered to the minimum allowable level by the circulating water pump and the blowdown piping. To completely drain the basin and pump intake chamber, a portable pump with hoses discharging into adjacent cooling tower basins will be required.

SECTION 19.0

AUXILIARY STEAM SYSTEM

The auxiliary steam system shown in Figure B30 will provide low pressure steam (400 psig at 550F) for plant services such as building heating and coal handling. During unit start-up and shutdown it will provide low pressure steam to the boiler feed pump turbines, steam air heaters, induced draft fan turbines, air ejectors, and various other equipment.

19.1 STEAM SOURCES

Auxiliary steam will be provided by auxiliary boilers or by extracting steam from the primary superheater outlet header of each main boiler and reducing the pressure to 400 psig. For start-up of the first unit, the only source of auxiliary steam will be the auxiliary boilers.

19.2 STEAM USE

The maximum non-coincidental auxiliary steam flow requirements will be as shown in Table 19-1.

TABLE 19-1

AUXILIARY STEAM REQUIREMENTS

	Service	Typical Maximum Flow Rate (lb/hr)
1.	Building heating (all units)	40,000
2.	Deaerator pegging (pressurizing, 5 psig with 1.5 in. Hg condenser vacuum)	61,000
3.	Air ejector	1,000
4.	Boiler feed pump turbines (to 25 percent load)	93,000
5.	Boiler feed pump turbine seals	600
6.	Induced draft fan turbines (to 30 percent load)	116,000
7.	Induced draft fan turbine seals	600
8.	Warm-up main turbine	35,000
9.	Main turbine seals	20,000
10.	Coal handling	36,000

Based on starting up one unit at a time, the maximum load demand by the auxiliary steam system on the auxiliary boilers will be 400,000 lb/hr.

The auxiliary boilers will not be used to supply steam to the steam air heater in a start-up mode. If steam is available from sister units for start-up, the steam air heater will be put into service. The steam air heater will require an additional flow of 133,000 lb/hr.

SECTION 20.0

COOLING WATER SYSTEM

The cooling water system will furnish cooling water for plant equipment such as:

1. Generator hydrogen coolers
2. Stator and exciter coolers
3. Main turbine lube oil and control fluid coolers
4. Boiler feed pump turbine lube oil coolers
5. Air compressor coolers
6. Forced draft and recirculation fan motors and bearings
7. Induced draft fan turbine lube oil coolers and bearings
8. Pulverizer lube oil coolers
9. Boiler circulation pumps
10. Air conditioners
11. Heater drain pumps
12. Laboratory sample coils

For the purpose of the preliminary engineering study, it was assumed that the total cooling water flow will be 10,500 gpm and the total heat dissipation will be 73 million Btu/hr.

The cooling water system shown in Figure B33 will be a closed system, and circulation through the equipment will be provided by pumps. After going through the equipment coolers, the heated cooling water will be pumped through heat exchangers where it will be cooled by circulating water. Vents will be provided in the high points of the system for removing air during filling and for bleeding air accumulated during operation.

20.1 COOLING WATER PUMPS

Three half-size electric motor-driven cooling water pumps rated at 5250 gpm, 125 ft TDH each, will circulate the water through the system. These pumps will be controlled from the main control room.

Each pump will be operated by a four-position STANDBY-OFF-AUTO-RUN switch mounted on the control panel located in the main control room.

The first pump will start on remote manual by placing its switch in the RUN position. The switch of the second pump will be in the STANDBY position for automatic starting when the system demands more water. The third pump will be for standby and emergency use.

20.2 INDIVIDUAL EQUIPMENT FLOW CONTROL

Control of the cooling water flow, when required, will be by throttling valves on the outlet of each piece of equipment. The throttling valves will be manually operated except for the boiler feed pump lube oil cooler, air conditioning units, and air compressors.

The manually operated valves will be adjusted for the desired flows during preliminary operations. Special temperature actuated control valves will regulate the flow through the boiler feed pump lube oil coolers, air conditioning units, and air compressors.

SECTION 21.0

COMPRESSED AIR SYSTEMS

The compressed air system, as shown in Figure B35, will consist of three air compressors for instrument and service air for each unit and two compressors for the boiler warm-up guns for each pair of units. The instrument and service air systems will be interconnected with the boiler warm-up gun system for additional flexibility if the need arises. All compressors will be of the oil-free type.

21.1 INSTRUMENT AND SERVICE AIR SUPPLY

The instrument and service air system will be served by three compressors, each with a capacity of 500 acfm at 100 psig. An aftercooler and an air receiver will be provided with each air compressor. The compressed air leaving the three air receivers will be manifolded into a common header from which one line will serve the instrument air system and another line will serve the service air system.

21.1.1 INSTRUMENT AIR SYSTEM

The instrument air system will supply air to the plant control systems shown in Figure B35. The instrument air system will be provided with prefilters followed by an air drying system and then by afterfilters.

There will be two prefilters arranged for parallel operation so that either one or both can be operated at any given time. Each prefilter will have isolating valves for element changing.

The air drying system will be of the dessicant type with two air drying units. One unit will be used to dry the air for use in the instrument air system while the other is being regenerated. Regeneration of an air dryer will be accomplished with an electric heater system which includes a cooler to cool hot air leaving the drying unit being regenerated.

The air from the drying system will go to an air reservoir sized to store sufficient air required to take the plant unit out of service in the event of loss of air compressor power supply. A check valve on the inlet of the reservoir will prevent loss of pressure by backflow if the air supply fails.

Two afterfilters in parallel will be provided after the air reservoir for final removal of contaminants before distribution to the instruments. Each afterfilter will have isolating valves for element changing.

Clogging of the prefilters and afterfilters will be detected by noting the pressure drop indicated by differential pressure gauges across the filters.

After the instrument air reservoir, all piping will be brass to assure that the air will not be contaminated by corrosion products.

Loop distribution systems will be used so that air will be supplied to each outlet connection from two directions and to provide a more even distribution.

21.1.2 SERVICE AIR SYSTEM

The service air system will distribute compressed air to various locations throughout the plant to operate miscellaneous tools and equipment. The air will be taken directly from the common discharge header of the three compressors.

21.2 WARM-UP GUN COMPRESSED AIR SYSTEM

Two compressors will supply air to the boiler warm-up guns. Each compressor will have a capacity of 1500 acfm at 100 psig and will discharge into a common air receiver.

SECTION 22.0

FIRE PROTECTION SYSTEM

Fire protection and fire detection systems will be provided throughout the entire plant to safeguard life and property. These systems are shown in Figure B36. Water spray, water sprinklers, water hydrants, carbon dioxide gas, halon gas, and foam systems will be used. All fire protection systems will comply with National Fire Protection and Occupational Safety and Health Standards Codes.

22.1 WATER SUPPLY

Two industrial water storage tanks with a total capacity of 8 million gallons will be provided, with 4 million gallons being reserved exclusively for fire protection. Four 2000 gpm main fire pumps and three 200 gpm jockey fire pumps will be provided for a maximum pumping capability of 8600 gpm for 8 hours from this reserve storage. In addition, two 2000 gpm emergency fire pumps could take water from the circulating water cooling tower basins simultaneously with the seven pumps drawing from the storage tanks to provide a total discharge of 12,600 gpm. Fire pumps will be started in sequence by pressure sensitive controls actuated by the water main pressure dropping below that normally maintained by the jockey pumps. The emergency diesel engine-generator will provide a secondary source of power to operate all fire pumps simultaneously.

A loop distribution system with 12-in. water mains will serve all major facilities, and branches from these mains will provide water to the entire plant. Fire hydrants will be provided at 300-ft spacing for hose stream fire protection.

22.2 TYPES OF SYSTEMS

Water spray systems will be provided for fire protection for equipment containing combustible or flammable liquids, selected coal handling areas, partial boiler burner deck areas, and boiler support columns.

Automatic water sprinklers will be provided for the ordinary hazards, such as warehouses and other buildings. Carbon dioxide fire protection will be provided for switchgear and electronic control rooms and selected coal-handling facilities. Halon gas fire protection will be provided in selected control cabinets frequented by plant personnel. A foam fire protection system will be provided for all fuel oil storage tanks; this system will be monitored and controlled from the control room with local control override.

22.3 FIRE DETECTION

Both ionization type combustible (smoke) detectors and combustible gas detectors will be used to detect hazardous conditions and to transmit alarms to control room alarm indicators. Operation of any automatic fire protection system will also cause the transmittal of alarms to control room alarm indicators.

22.4 ADDITIONAL PROTECTION

In addition, a fire engine pumper truck, wet standpipes, and portable fire extinguishers will be provided for use by plant personnel to extinguish fires in areas not covered by automatic systems.

SECTION 23.0

GENERATOR HYDROGEN AND CARBON DIOXIDE SYSTEMS

23.1 HYDROGEN SYSTEM

The hydrogen system shown in Figure B37 will supply hydrogen to the turbine generators for generator cooling. The system will consist of two storage banks. Each bank will have 96 cylinders with 16 reserve cylinders for a total of 77,000 scf at 2000 psi. Approximately 35,000 scf will be required to fill each generator and the expected leakage is 500 scf/day per unit. Two units will be served by each bank and a common header will connect the two banks for greater flexibility.

The pressure of the hydrogen gas at each bank will be reduced to 150 psig by a pressure regulator before being supplied to each unit. A connection will be provided at each bank for filling from a tank truck.

A safety shut-off valve will be provided in the supply line to each unit in order to protect against loss of hydrogen gas supply to the other units in the event of a rupture in the supply line.

23.2 CARBON DIOXIDE SYSTEM

The carbon dioxide system shown in Figure B37 will include two storage tanks which supply carbon dioxide gas to displace the hydrogen in the generator before it is opened for maintenance. Each storage tank will contain 4 tons of liquid carbon dioxide at 300 psig and 0 degree F which is sufficient to purge one generator. Each tank will be connected to a common header which will serve any generator. A refrigeration unit at each tank will maintain the liquid carbon dioxide at 0 degree F. A bleeder relief valve will relieve a small amount of carbon dioxide when the refrigeration unit is not in service. In addition, there will be two safety valves per tank as required by the ASME pressure vessel code. Each tank will be provided with a connection for tank truck delivery of liquid carbon dioxide.

The liquid carbon dioxide will be vaporized by a heater for use in generator purging. The carbon dioxide gas pressure will be reduced from 300 psig to 60 psig by a pressure regulator before being supplied to the generator.

23.3 VENTS AND DRAINS

Hydrogen will be vented above the top of the boiler structure and drains will be provided to the condenser pit to ensure safe and positive venting and draining of hydrogen gas and carbon dioxide gas from each generator.

SECTION 24.0

AUXILIARY BOILERS

Two auxiliary boilers, located as shown in Figure B5, will supply steam to the common plant auxiliary steam headers described in Section 19.0. Each auxiliary boiler will produce 225,000 lb/hr of steam at 400 psig and 550F at the superheater outlet, with feedwater at 228F when firing No. 2 fuel oil. About 25,000 lb/hr of steam will be required to operate the auxiliaries of each auxiliary boiler, leaving a total of 400,000 lb/hr of auxiliary steam to start up a unit. When only one unit is in operation, one auxiliary boiler will be kept in operation continuously. This will assure continued operation of the turbine-driven induced draft fans to purge the boiler and to supply steam to the turbine seals after a unit trip. This will also assure a supply of steam for other needs throughout the plant such as coal handling and building heating.

24.1 AUXILIARY BOILER UNITS

The two auxiliary boilers will be shop-assembled package boiler units with the following equipment:

1. Boiler
2. Burners and ignitors (steam and air atomizing burners and oil electric ignitors)
3. Combustion air supply (forced draft fan)
4. Fuel oil pumps and heaters
5. Superheater
6. Boiler and burner control systems
7. Automatic safety controls
8. Control panel
9. Soot blowers
10. Stack
11. Heating coils
12. Economizer

The boilers will generate superheated steam at 400 psig and 550F within a range of about 10,000 to 225,000 lb/hr.

Single or multiple burners will provide boiler operation from minimum to maximum steam flows. During cold boiler start-ups, the burner guns will use air atomization and during normal operation will use steam atomization. The guns will be capable of being withdrawn when not firing. Observation ports will be provided for boiler flame viewing.

A forced draft fan, provided with each auxiliary boiler, will be capable of delivering 300,000 lb/hr of air at a static pressure of 32 in. of water and will be driven by a 500-hp motor.

Each auxiliary boiler will be provided with two fuel oil pumps and two fuel oil heaters for reliability. The heaters will heat the No. 2 fuel oil to a temperature required by the boiler for proper operation. One of the heaters will be an electric-steam heater for cold boiler start-up when heating steam is unavailable.

A common local control panel for the two auxiliary boilers will be located adjacent to the boilers. The auxiliary boiler control systems are described in Section 36.5.7.

Each boiler will have a steel stack, 60 ft high with an inside diameter of approximately 84 in. at the exit.

A heating coil system will be provided in each lower boiler drum to pressurize the boiler and keep it warm. This will keep the superheater dry and the auxiliary boiler warm and ready for quick starts. Condensate from the heating coils will drain through traps to the blowdown tank.

Each boiler will have an economizer to increase efficiency. The economizer will limit the outlet flue gas temperature to a maximum of 300F. The economizer tubes will be either of spiral-finned steel or cast-iron construction and will be mounted in the flue gas outlet of the boiler. The water temperature will be limited to 10F below the saturation temperature of the water entering the boiler. The economizer will be furnished with soot blowers.

During an initial cold start, the boiler will be able to reach full load in about 3 hrs. When starting from the hot standby condition, the boiler will produce full output in 60 minutes. During normal operating conditions, the maximum permissible rate of load variation will be about 45,000 lb/hr/minute.

Continuous blowdown of the steam drum on each boiler through a manually operated blowdown valve will be used to assist in controlling the boiler steam and water quality.

24.2 ACCESSORY SYSTEMS TO AUXILIARY BOILER

24.2.1 FEEDWATER SYSTEM

Condensate will be conveyed from the plant condensate transfer pump header by two 450 gpm, 115 ft TDH condensate pumps. A third full-sized standby condensate pump will also be installed. The rate of water flow to the deaerator will be regulated by control valves that maintain a normal level in the deaerator storage tank. The deaerator pressure will be maintained at 5 psig by steam from the auxiliary boilers regulated by a control valve and a pressure controller. Air and noncondensable gases will be discharged to the atmosphere through a vent valve. A stainless steel vent condenser will be provided to reduce the amount of steam vented. The deaerator storage tank will have about 10 minutes of storage capacity of 228F condensate. Two 500 gpm, 1310 ft TDH boiler feed pumps will pump condensate from the deaerator storage tank, through the economizers, to the boilers. A third full-sized standby boiler feed pump will also be furnished.

The treatment of the feedwater for the auxiliary boilers is described in Section 34.6.

24.2.2 AUXILIARY BOILER STEAM SUPPLY SYSTEM

The superheated steam from one boiler will combine with the steam from the other boiler through separate check valves and stop valves. Superheated steam from the auxiliary boilers will enter the plant auxiliary steam header as a primary source of steam for the auxiliary steam system.

24.2.3 BLOWDOWN TANK

A boiler blowdown tank will be furnished to receive auxiliary boiler blowdown, heating coil drains, and boiler header drains. The tank will operate at about 2 psig. Steam will be vented to the atmosphere, and the remaining water will drain to the auxiliary boiler drain sump.

SECTION 25.0

AUXILIARY FUEL OIL SYSTEM

The auxiliary fuel oil system, as shown in Figure B38, will supply fuel oil to the main boiler ignitors and warm-up guns and to the auxiliary boiler burners. It will also supply fuel oil to the auxiliary diesel engine generator fuel oil storage tank. The system will use No. 2 fuel oil and will consist of a fuel oil unloading pump, fuel oil transfer pump, two fuel oil storage tanks, one underground overflow holding tank, and three half-size fuel oil service pumps.

25.1 FUEL OIL STORAGE SYSTEM

Provision will be made to accept delivery of fuel oil by either truck or rail. Fuel oil will be pumped by the unloading pump and stored in one of two 75,000-barrel storage tanks surrounded by dikes. The quantity of delivered fuel oil will be measured by volume displacement in the storage tanks with a temperature correction factor being applied. Storage capacity will be in excess of 2 months maximum expected usage. Fuel oil will be transferred from one storage tank to the other by a transfer pump. Each tank will be protected by an overflow line discharging to a common underground overflow holding tank which will act as a sump in case of fuel expansion or overfilling.

25.2 FUEL OIL SUPPLY AND RETURN SYSTEM

Three half-size fuel oil service pumps, rated at 118 gpm, 900 ft TDH, will supply the main fuel oil header. A return line from the main fuel oil header will connect to the storage tanks through a pressure reducing station to provide for recirculation.

SECTION 26.0

AUXILIARY DIESEL ENGINE GENERATORS

Two 800-kw auxiliary diesel engine generator units, located as shown in Figure B5, will generate sufficient electrical power to operate all necessary equipment to safely shutdown the plant in the event of loss of normal power sources, and to maintain the plant in a shutdown mode until normal power sources are restored. The units will be enclosed for outdoor service.

The diesel engine generator units will operate in the AUTOMATIC, LOCAL-MANUAL, and REMOTE-MANUAL modes. The selection of the modes will be made by the control operator. Power from the diesel engine generator units will be fed into the emergency power system described in Section 43.0.

Fuel for the diesel engine generator units will be supplied from the auxiliary fuel oil system described in Section 25.0. Oil will be stored in one 2000 gal underground storage tank near the diesel engine generator units to allow continuous operation of both units for a minimum of 10 hr, independent of the auxiliary fuel oil system. One 50 gal tank will be provided for each unit to start the engine.

SECTION 27.0

CRANES, HOISTS, AND ELEVATORS

Two turbine bay bridge cranes, two A-frame gantry cranes, and various smaller hoists for erection and maintenance will be provided for the plant. An elevator will be provided between each pair of units and also in each stack.

27.1 CRANES

27.1.1 TURBINE GENERATOR BAY BRIDGE CRANES

Two bridge cranes, as shown in Figures B4 and B13, will provide the lifting capability for erection, repairs, and maintenance of the four turbine-generator units and various other equipment located within the turbine bay. These cranes will not have the capacity to lift the generator stator or the lower half of the various turbine casings which can be jacked into place. Each crane will have a main hook with a capacity of 100 tons and auxiliary hooks with a capacity of 15 tons. The span will be 120 ft.

27.1.2 TURBINE GANTRY CRANE

Two turbine gantry cranes, as shown in Figure B4, will be provided to facilitate erection, repairs, and maintenance of turbine valves, bearings, and other equipment. Each crane will have a hook capacity of 3 tons and a span of 56 ft.

27.2 HOISTS

Various monorail hoists will be installed throughout the plant for maintenance and repair of equipment.

27.3 PLANT ELEVATORS

An elevator for transporting passengers and material will be located between each pair of units near each control room as shown in Figure B15. Each elevator will have a capacity of 6000 lb, a cab size of 6 x 6 ft, a speed of 350 fpm, automatic pushbutton controls, and a travel of 248 ft with ten landings. The elevator machine room will be located as shown in Figure B5.

27.4 STACK ELEVATOR

A six-man elevator will be provided in each of the two stacks to transport personnel between the ground and the top of the stack. The elevator will be located between the two circular steel flue gas ducts and the outer concrete shell.

SECTION 28.0

HEATING, VENTILATING, AIR CONDITIONING, AND PLUMBING FOR MAIN POWER PLANT STRUCTURE

All areas of the control bay structure and the turbine-generator bay structure will be provided with heating, ventilation, or air-conditioning suitable to the functions which they will perform. For design purposes the outside air is assumed to be 98F dry bulb and 68F wet bulb in summer and 0 degree F dry bulb in winter.

28.1 CONTROL BAY STRUCTURE

The following areas in the control bay structure will be provided with conditioned air at 75F plus or minus 2F dry bulb temperature and 50 percent maximum relative humidity:

1. Control room
2. Shift foreman's office
3. Chart room
4. Test engineers and conference room
5. Chemical laboratory
6. Kitchen
7. Toilet room
8. Locker room
9. Terminal room
10. Instrument repair shop
11. Communication room
12. Relay room
13. Battery rooms

The chemical feed room will be ventilated and maintained at 50F minimum dry bulb temperature and the switchgear room will be ventilated only.

28.2 TURBINE-GENERATOR BAY STRUCTURE

The interior of the turbine-generator bay structure will be ventilated and maintained at a positive pressure to minimize dust infiltration. Air temperatures will be limited to 95F dry bulb maximum in summer by evaporative cooling and 50F minimum in winter by steam coil heaters. Perimeter steam unit heaters on the ground floor will maintain 35F throughout the building at all times to provide freeze protection.

SECTION 29.0

CHEMICAL AND FUEL LABORATORIES

29.1 CHEMICAL LABORATORY

A chemical laboratory to monitor water quality will be located in the control bay for each pair of units as shown in Figure B15.

The purpose of the chemical laboratory, with its manual and automatic testing facilities, is to monitor and control the quality of water used in the steam water cycle and the circulating water system. The use of chemical treatment to control water quality, regardless of the excellence of the materials employed, is impossible unless such treatment is closely controlled by means of daily chemical laboratory tests. The chemical laboratory will be equipped to perform tests for hardness, alkalinity, chloride, hydrazine, phosphate, silica, sodium, iron, and specific conductance, for dissolved solids.

Purposes of chemical laboratory tests for monitoring water quality in the plant are as follows:

1. To ascertain that the various components of the cycle, such as the chemical feed pumps, are operating correctly with relationship to the steam and water chemical quality within the cycle concerned.

2. To determine that preventable corrosion is not taking place.

3. To determine that undesirable amounts of foreign material, such as air and circulating water, are not leaking into the cycle.

4. To supply control instruments of the chemical feed system adequate signals to control the injection of chemicals to the cycle for maintaining proper chemical quality.

5. To supply control instruments of the "makeup and drawoff system" control signals to operate automatic control valves for the purpose of discharging contaminated condensate not suitable for use in the cycle, or diverting excess usable condensate to storage.

6. To monitor the chemical quality of steam and feedwater during lay-up, cycle cleanup, and start-up operations.

7. To provide a manual means for monitoring the chemical quality of the circulating water to determine the need for chlorination or other chemical treatment.

8. To provide a manual means to monitor the chemical quality of the cooling water to determine the need for adding corrosion inhibitors.

29.2 FUEL LABORATORY

The fuels laboratory, located within the warehouse and shops building as shown in Figure B16, is required to determine whether the coal and fuel oil used are within purchase specifications.

The laboratory will be equipped to monitor the following coal properties:

1. Heating value
2. Sizes and grades
3. Proximate analysis
4. Ultimate analysis
5. Ash analysis
6. Uniformity
7. Friability
8. Grindability
9. Storage characteristics
10. Coking and caking tendency
11. Slagging characteristics including ash fusion temperature
12. Ignition characteristics

The laboratory will also be equipped to monitor the following fuel oil properties:

1. Flash point
2. Pour point
3. Viscosity
4. Specific gravity
5. Heating value
6. Ash content
7. Ultimate analysis

SECTION 30.0

MAINTENANCE AND REPAIR SHOPS EQUIPMENT

Shop facilities, as shown in Figure B16, will consist of a machine shop, welding and pipe shop, electrical repair shop, and automotive repair shop. Maintenance and repairs to plant equipment such as conveyors, pulverizers, pumps, blowers, compressors, bearings, valves, motors, and electrical switchgear will be performed in these shops. Also, minor structural and piping modifications will be performed. These facilities will ensure operating reliability and will provide services during major overhauls of the units.

Major machine tools to be provided in the machine shop are a 5-ft radial drill, milling machine, power metal saw, portable threading machine, and a 21-in. engine lathe capable of machining large components of the coal pulverizers.

An automotive service shop will also be provided for routine maintenance and repair of vehicles, such as oil change, lubrication, fueling, tune-ups, engine repair, steam cleaning, and painting. It will be equipped with pneumatic lifts, air compressor, lubrication, steam cleaning, and paint spray equipment.

SECTION 31.0

PLANT WATER BALANCE

A plant water balance, as shown in Figure B41, accounts for water sources to, water uses in, and discharges from the plant. The major categories of water use are:

1. Cooling tower evaporation and drift loss
2. SO2 scrubber evaporation loss
3. Ash and sludge disposal loss
4. Wastewater and miscellaneous losses

The yearly water consumption, under normal weather conditions and at an 85 percent plant capacity factor, is estimated to be 24,300 gpm (39,200 acre-ft/yr). The design water consumption for all four units operating at a 100 percent capacity factor during the summer months is approximately 33,000 gpm.

Water will be supplied from the surface and underground water systems. A preliminary chemical analysis of the two sources is shown in Table 31-1.

31.1 MAJOR WATER USES

Major water uses have been estimated for an average yearly consumption based upon normal weather conditions and at an 85 percent plant capacity factor.

31.1.1 COOLING TOWER EVAPORATION AND DRIFT LOSS

The largest water loss in the plant will be evaporation and drift from the cooling towers. The average yearly water consumption for evaporation and drift is estimated to be 20,700 gpm (33,400 acre-ft/yr) for the four units. At 10 cycles of concentration the cooling tower blowdown will be 2200 gpm. The total makeup water required by the cooling towers will be 22,900 gpm.

31.1.2 SO2 SCRUBBERS

The average annual water consumption for evaporation in the SO2 scrubber is estimated to be 2500 gpm (4035 acre-ft/yr) for the four units. Estimated average evaporation for 85 percent plant capacity factor is 5135 gpm. Moisture in the combustion air and water vapor in the coal is estimated to be 2635 gpm.

TABLE 31-1

PRELIMINARY CHEMICAL ANALYSIS OF WATER SUPPLY

	Fremont River (ppm)	Well Water (ppm)
Calcium	88	292
Magnesium	29	92
Total Hardness	340	1105
Sodium	25	493
Potassium	5.4	5.0
Alkalinity	146	194
Sulfate	213	1076
Chloride	19	625
Silica	25	12
Nitrate	2.0	0.2
Phosphate	0.48	---
Total dissolved solids	556	2900

31.1.3 ASH AND SLUDGE

Through the boiler bottom ash system, 120 gpm of water will be lost with ash disposal. Water lost with sludge streams will consist of 80 gpm from the lime makeup softener thickeners and 150 gpm from the SO2 scrubber sludge. The average total loss will be 350 gpm (565 acre-ft/yr).

31.1.4 WASTEWATER AND MISCELLANEOUS WATER LOSSES

Wastewater and miscellaneous water losses include service water, boiler venting and leakage, boiler wash, demineralizer, dust suppression, boiler feed makeup softener waste, and other miscellaneous systems. The average total loss is estimated to be 755 gpm (1210 acre-ft/yr).

SECTION 32.0

INDUSTRIAL WATER SYSTEM

The industrial water system, as shown in Figure B34, distributes water within the plant from the surface water supply system and the underground water supply system which are described in Section 6.0.

The industrial water system receives water from the surface water system supply line at the motor-operated butterfly Valve V-RWH19 and also receives water from the underground water supply line at the motor-operated butterfly Valve V-RWH20. Water is distributed from the industrial water system to the domestic water clarifier, surface water storage tank, groundwater storage tank, SO2 scrubber lime slaker, coal dust suppression system, boiler wash pumps, air heater wash systems, lime makeup water softener, and filter system and is the supplementary supply to the scrubber water storage tank. Water is also supplied for wash down purposes to the coal handling area and other areas of the plant.

Six 10,000 gpm, 300 ft TDH industrial water pumps will maintain pressure in the system. Water in the two storage tanks will be used for emergency supply and for fire protection.

32.1 STORAGE TANKS

The 5 million-gal surface water storage tank will have a 3 million-gal reserve for fire protection and 2 million gal will be available for other plant uses. The 3 million-gal groundwater storage tank will have a 1 million-gal reserve for fire protection and 2 million gal will be available for other plant uses.

The discharge nozzles to the fire protection system will be located at the bottom of the tanks so that all water in the tanks will be available for fire protection. The discharge nozzles to supply all other plant uses will be located above the emergency fire protection volumes to assure that a minimum of 4 million gal of water will be available for fire protection at all times. An additional nozzle located at the bottom of each tank to allow draining of the tank into the industrial water system will be blocked by a normally locked valve to prevent accidental loss of the fire protection reserve water.

32.2 LIME MAKEUP SOFTENER FILTER SYSTEM WATER

A portion of the industrial water that will be treated by the lime makeup softener filter system, described in Section 34.2, will be returned to the intake manifolds for the service water pumps. Three service water pumps having capacities of 300, 600, and 3000 gpm, and all having 200 ft TDH, will be provided for each pair of units. The service water pumps will provide water for seal water service, evaporator descaling, condenser fill, acid cleaning, sawdust injection, and the condenser cleaning station.

32.3 SCRUBBER WATER STORAGE TANK

The scrubber water storage tank will have a capacity of 250,000 gal. The major source of supply to the storage tank will be the blowdown from the cooling towers. The water from the tank will be piped to the intake manifold of four 1600 gpm, 150 ft TDH scrubber water makeup pumps which will supply water to the bottom ash and SO_2 scrubber systems.

SECTION 33.0

DOMESTIC WATER SYSTEM

The plant domestic water system will take water from the surface water supply line or the surface water storage tank of the industrial water system and supply potable water to the showers, toilets, lavatories, drinking fountains, and food service facility at various locations throughout the power plant complex.

The system consists of a domestic water treatment facility, pumps, a domestic water storage tank, a domestic water head tank, and all related piping. The raw surface water will be treated, pumped to the storage tank, then pumped to the head tank for distribution to the many domestic use fixtures.

33.1 SOURCE

The source of the domestic water will be the Fremont River as supplied to the plant by the surface water system via the reservoir as described in Section 6.3. At the power plant, the surface water is supplied to the plant industrial water system which will have connections provided on the supply line and the surface water storage tank to supply raw water to the domestic water system.

33.2 DEMAND

On the average, there will be a total of 380 workers at the power plant in any 24-hr day. The average daily consumption is estimated at 40 gpd for each of these workers. Based on this estimate, the domestic water system will meet the following consumption requirements:

1.	Average daily	15,200 gpd	10.6 gpm
2.	Maximum daily	27,400 gpd	19.0 gpm
3.	Maximum hourly	2,280 gph	38.0 gpm

33.3 TREATMENT

The domestic water will be treated to comply with all applicable Utah codes and the United States Public Health Service Drinking Water Standards. As much as 95 percent of the settleable solids found in the water at the river will be removed during the storage interval in the reservoir. This storage constitutes presedimentation.

The treatment facilities will be housed in the water treatment building, located as shown in Figure B1. Treatment at the plant site will consist of prechlorination, clarification, and filtration to reduce turbidity and postchlorination. The water will be softened to a total hardness of about 70 ppm, expressed as calcium carbonate, with partial reduction in alkalinity. Iron and sulfate found in the raw river water may have to be reduced by appropriate treatment.

33.4 STORAGE

Raw surface water can be supplied from the 5-million gal surface water storage tank of the industrial water system. After treatment, the domestic water will be pumped to the steel domestic water storage tank located above grade near the water treatment building. The tank will have a capacity of 55,000 gal, representing a 2-day water supply of treated domestic water at maximum daily consumption. This storage tank will be provided to assure an adequate supply of treated domestic water during periods of interruptions in the treated water supply such as maintenance of domestic water treatment equipment or pumps. The domestic water head tank, located in the boiler building at an approximate elevation of 5060 ft will have a capacity of 7000 gal representing a 6-hr supply.

33.5 PUMPS

A 4-hp pump, backed by a 4-hp spare pump, will pump water from the treatment facility to the domestic water storage tank. Additionally, two 8-hp pumps, one being a spare, will pump water from the storage tank to the domestic water head tank.

SECTION 34.0

WATER TREATMENT SYSTEMS

This section describes all water treatment systems for the plant except for treatment of the domestic water system as described in Section 33.4. The industrial water system described in Section 32.0 supplies water to the water treatment systems described in this section. A flow diagram of the water treatment systems is shown in Figure B41. Water treatment systems are located in the Water Treatment Building shown in Figure B1.

34.1 LIME MAKEUP WATER SOFTENER AND FILTER SYSTEM

Under full load conditions the water flow to the lime makeup water softener and filter system, as shown in Figure B42, will be 31,000 gpm, of which more than 90 percent will be used by the cooling water system. To permit the circulating water system to be operated at approximately 10 cycles of concentration, the industrial water must be treated to reduce the scale forming elements, calcium and magnesium (hardness). In addition to removing hardness, the silica and turbidity will simultaneously be reduced to further improve the industrial water for general service use.

The chemicals used in the lime makeup water softener will be lime and a suitable coagulant added to propagate the chemical precipitating reactions. Softened water will be supplied directly to the cooling towers. The remaining water will be fed to pressure filters which will remove suspended matter resulting from the softening process.

34.1.1 LIME MAKEUP WATER SOFTENER

Three makeup softeners will be provided. Each softener will be capable of treating water at a rate of 15,000 gpm. The excess capacity has been provided for the purpose of meeting extreme conditions and providing an adequate water supply with one softener out of service.

Lime will be added to industrial water entering the softeners to remove calcium and magnesium hardness by precipitation. The precipitation will be accelerated by the addition of a coagulant and a coagulant aid. The resulting sludge will be pumped periodically from the bottom of the softener to the sludge thickeners.

Three sludge thickeners will be connected to the softeners to receive the precipitated sludge for further concentration. The clarified liquid overflow will be routed to the slurry water tank and the concentrated sludge will be disposed of in the ash disposal area either by incorporating with the fly ash and scrubber sludge at the plant or by mixing with the fill at the disposal area.

The softened water will be collected at the top of each softener and distributed to the circulating water system and to the pressure filters. A clearwell of 100,000 gal capacity will be provided between the softeners and the pressure filters. The clearwell will act as a surge and storage tank, accommodating sudden increases of water flow resulting from pressure filter backwashing operations.

Two 120,000-lb capacity lime storage bins each feed one lime slurry feed tank. The lime slurry feed tank will mix 1 part lime with 9 parts water to produce a 10 percent lime slurry. Two 55-gpm, 70-ft TDH, full-size pumps will feed the lime slurry into the softeners. The lime dosage is estimated to be 1 lb per 1000 gal of softened industrial water.

The optimum coagulation is usually carried out within a narrow range of pH values which will be determined by experiment when this system begins operation. A small amount of coagulant aid is fed into the softener to broaden the pH range in which good coagulation takes place. Two coagulant aid tanks and two coagulant aid feed pumps will be provided in the system. A coagulant will be fed into the softener simultaneously with the lime slurry. A 10,000-gal coagulant tank will be provided. Two full-size coagulant feed pumps will transfer the coagulant solution into the softeners. Two coagulant aid tanks and two full size coagulant aid feed pumps will be provided in the system.

34.1.2 PRESSURE FILTERS

Five 270-gpm vertical pressure filters will be provided, one of which will be a spare. Three half-size, 450-gpm, 260-ft TDH booster pumps will pump the softened water through the pressure filters.

The suspended matter removed by the filters will accumulate on the filter surface; the increased frictional resistance will be indicated by a pressure gage. When the pressure differential reaches a certain limit, backwashing of the filter will be initiated. The backwash rate will be several times higher than the normal water flow. Two full-size backwash pumps will be provided. Backwashing usually continues from 10 to 30 minutes, after which the filter is returned to service.

The water coming from the filters will be sent to the boiler feed makeup softener system and various other locations.

34.1.3 SLURRY WATER TANK

A slurry water tank of 50,000 gal capacity will be provided to store backwash water from the pressure filters, the overflow from the sludge thickeners and lime makeup water softeners, and the discharge from local water sampling stations. After settling, the slurry water will be sent to the SO2 scrubbers or recycled to the lime makeup water softeners.

34.2 CIRCULATING WATER CHEMICAL TREATMENT SYSTEM

The purpose of the circulating water chemical treatment system is to prevent scaling, corrosion, and biological fourling problems. Chlorine, acid, a corrosion inhibitor, and a dispersant will be added as required. This system is shown in Figure B43.

Impurities in the cooling tower circulating water become concentrated due to evaporation of a portion of the circulating water as it passes through the cooling tower. The concentration of impurities in the circulating water will be maintained at 10 times their concentration in the makeup water. Unless corrected by chemical treatment, the increased concentration raises the pH of the water, which would result in damage to the tower and scale formation in the circulating water system.

The intimate contact between the cooling water and the air passing through the cooling tower continuously saturates the water with dissolved oxygen. This corrosive gas is the major cause of corrosion. Besides oxygen, the concentrations of dissolved solids and dissimilar metals in the recirculating system also cause corrosion problems.

Biological fouling is also found in cooling water systems as the result of excessive growth and development of different members of the lower forms of plants, namely, algae and fungi. They are commonly found in all surface water supplies.

34.2.1 CHLORINATION SYSTEM

Chlorination of the circulating water system will be employed for the control of biological growth in the condenser and in the circulating water system piping. Chlorine will be introduced intermittently into the circulating water.

The chlorination system will consist of a liquid chlorine storage tank, two chlorine evaporators, two chlorinators, two chlorine injectors, and two chlorination water booster pumps. Redundancy will be designed into the chlorination system for reliability. Liquid chlorine will be taken from the storage tank to the evaporator where chlorine will be evaporated to a gas. The gas will flow through a pressure reducing valve to the chlorinator which measures and feeds the required dosage of chlorine to the chlorine solution line through an injector. The chlorine solution will be injected into the main flow of the circulating water. An adjustable repeat-cycle timer will be provided to automatically start the chlorination cycle at a preset time interval.

Each 300-gpm, 370-ft TDH chlorination water booster pump will transfer chlorine solution into the circulating water. The chlorine dosage will be determined by monitoring the residual chlorine at the discharge of each condenser.

One chlorination system will be shared by each pair of units and an interconnection will be provided between the two systems to ensure proper chlorination for all four units when one system is out of service.

34.2.2 CIRCULATING WATER ACID TREATMENT SYSTEM

To prevent scale formation, sulfuric acid will be fed into the circulating water at the cooling tower basin to maintain a pH level of 6.5 to 7.0. One common acid treatment system will be provided for each pair of units. An acid storage tank of 30,000 gal capacity will be provided for each system. The acid will be fed through four acid metering pumps rated at 0 to 15 gph each. A fifth pump will be available as a spare. The rate of feed will be regulated by a signal from an instrument measuring the pH of the circulating water pump discharge.

34.2.3 CORROSION INHIBITOR FEED SYSTEM

One corrosion inhibitor system will be installed for each pair of units. Polyphosphates will be used for corrosion control in the circulating water system. The chemical will be fed into a storage tank and dissolved in water. The solution will be transferred intermittently by three 30-gph, 100-psig pumps into the main circulating water system. One of the three pumps will be a spare.

34.2.4 DISPERSANT FEED SYSTEM

One disperant feed system will be installed for each pair of units. The dispersant's cleaning or dispersing action prevents the buildup of scale and iron oxide turberculation (pitting) products, maintaining the interior surface of the circulating water system piping in a relatively clean condition and thereby reducing friction losses. The dispersant will be fed into a storage tank and dissolved in water. The solution will be transferred intermittently by three 30-gph, 100-psig pumps into the main circulating water system. One of the three pumps will be a spare.

34.2.5 CONTROL OF IMPURITIES

The concentration of impurities in the circulating water will be controlled by blowdown as shown in Figure B41. The amount of blowdown is controlled by measuring the conductivity of the circulating water. It is expected that the circulating water will be maintained at 10 cycles of concentration.

34.3 BOILER FEEDWATER MAKEUP SOFTENER SYSTEM

The boiler feed makeup softener system, as shown in Figure B44, will be used to reduce the hardness of the water supplied to the evaporator to less than 1 ppm.

The evaporator used for producing boiler makeup water requires that the incoming water be limited to a maximum total hardness of 1 ppm of calcium carbonate. This level of hardness cannot be achieved by lime softening alone. Therefore, further treatment of the water coming out of the lime softener and pressure filter system must be provided before the water enters the evaporator. Sodium zeolite softeners will be used for boiler feedwater makeup treatment because they remove almost all hardness and are easy to operate and control.

Four sodium zeolite softeners with a total treatment capacity of 760 gpm will be provided for the plant. Three softeners will handle the normal flow with the fourth one being a spare. The softeners will be pressure type softeners with automatic and manual control.

Water coming from the pressure filters will flow through the zeolite (sodium cation-exchanger) bed, which removes calcium and magnesium from the water and gives up an equivalent amount of sodium in exchange. The softened water will have a hardness of less than 1 ppm and will be sent to the evaporator for boiler feedwater makeup.

When the zeolite approaches exhaustion in the softening process, the hardness of the effluent from the softener will rise quite rapidly. Therefore, the softeners must be regenerated before they approach complete exhaustion.

In regenerating the zeolite softener, it will first be backwashed to expand and clean the bed. Backwashing will be accomplished by passing a strong flow of water upwardly through the zeolite bed at a rate of between 5 to 8 gal per sq ft per minute. Following the backwashing a predetermined amount of salt brine will be passed through the softener from the top to regenerate the zeolite resin by exchanging sodium for the calcium or magnesium ions. A wet salt storage tank will be used to provide an adequate supply of salt for a large number of regenerations. Two 5-gpm, 45-ft TDH brine pumps will transfer the strong salt solution to the softener from the wet salt storage tank. Lastly, salt-free system water will be added to the top of the softener to displace the salt water or brine through the bottom of the softener to waste. Rinsing will be continued until all salt is washed from the bed, and then the softener will be returned to service.

34.4 MAIN BOILER WATER CHEMICAL FEED SYSTEM

The main boiler water chemical feed system, as shown in Figure B45, will chemically adjust the quality of the water in the steam-water cycle for control of scaling and corrosion of the equipment in the cycle. One boiler water chemical feed system will be supplied for each pair of units. The chemicals used will be phosphate for the control of surface scale, hydrazine for oxygen scavenging, and ammonium hydroxide for pH control.

Seven positive displacement pumps will be provided for each system. They will consist of two 6-gph, 350-psig hydrazine pumps; two 26-gpm, 3600-psig phosphate pumps; two 13-gph, 350-psig ammonium hydroxide pumps for each unit; and one 13-gph, 350-psig spare pump. The following five tanks will be provided for each system to store the chemical solutions:

1. 1 300-gal tank for phosphate
2. 1 500-gal tank for hydrazine
3. 1 300-gal spare tank for hydrazine or phosphate
4. 1 9000-gal tank for concentrated ammonium hydroxide
5. 1 1000-gal tank for dilute ammonium hydroxide

Each of the ammonium hydroxide tanks will be vented to a water seal scrubber to eliminate the pungent odor of any ammonia vapors.

34.5 AUXILIARY BOILER WATER CHEMICAL FEED SYSTEM

The auxiliary boiler water chemical feed system, as shown in Figure B45, will chemically adjust the quality of the water in the auxiliary steam-water cycle for control of scaling and corrosion of the equipment in the cycle. This system will use some chemicals that are different from those used in the main boiler feedwater chemical feed system due to the different steam conditions. Phosphate will be used in the auxiliary boilers for surface scale control as in the main boilers, but sulfite will be used for oxygen scavenging instead of hydrazine because of the better reactivity of sulfite at the lower fluid temperatures. Amines will be used for pH control instead of ammonium hydroxide because some of the steam from the auxiliary boilers will be vented to the atmosphere after use and ammonium hydroxide would cause an objectionable odor.

34.6 WATER SAMPLING AND CHEMICAL TESTING SYSTEM

The water sampling and chemical testing system, as shown in Figure B46, will sample water from various points in the steam-water cycles, the circulating water system, the cooling water system, and the blowdown tank. These samples will be tested to allow the control of chemicals to be maintained within acceptable ranges.

Condensate quality will be controlled and maintained in order to prevent corrosion and formation of objectionable solid deposits in the boiler, turbine and turbine cycle piping, and equipment. The sampling systems, consisting of lines terminating in the chemical laboratories or at local points, will afford a means of constantly monitoring water quality at points within the cycle so that in the event the chemistry of the steam-water cycle reaches abnormal values, remedial action can be taken. In addition, local sample points will be provided to collect samples for chemical laboratory analysis to study unusual conditions and to check automatic instruments. Portable sample coolers will be used where required.

One sampling system will be provided for each unit and will consist of sampling nozzles, analyzers, recorders, and necessary piping. The samples will be reduced to optimum test pressures and temperatures with the aid of pressure reducing and cooling water systems. Sample pumps will be used for samples under negative pressure. The quality of samples will be continuously monitored and recorded and an annunciator system will be provided to alarm abnormal conditions. Clean sample drain water will be recovered. Relief valves will be provided in the sample lines where required for operator safety and for protection of analyzing equipment.

The following measurements will be made close to the sample takeoff points to eliminate time lag and ensure accuracy: 1) conductivity measurements in the condenser hotwell, deaerator outlet, and evaporator blowdown; and 2) turbidity measurements at the economizer inlet. All other steam-water cycle sampling system instruments will be located on a control board in the chemical laboratory including those to monitor iron, silica, dissolved oxygen, hydrazine, phosphate, and pH.

34.7 AUXILIARY DEMINERALIZER SYSTEM

The plant auxiliary demineralizer system, as shown in Figure B47 and located in the water treatment building shown in Figure B1, will provide the prefiring rinse and flush water for the main boilers, as well as the initial condensate supply for the main and auxiliary boilers. The demineralizer system will also serve as an additional source of condensate during initial testing of the units since the evaporators will not produce an adequate makeup water supply while the units are operating below half load. Any excess demineralized water will be stored in the condensate storage tanks.

The auxiliary demineralizer system will consist of a single train of components including a primary cation exchanger followed sequentially by a primary anion exchanger, a secondary cation exchanger, and a secondary anion exchanger. Supplemental equipment will include an 11,000-gal acid storage tank and a 12,500-gal caustic storage tank. These tanks will supply the chemicals used to regenerate the anion and cation resins and, in addition, will also supply caustic to neutralize any acidic demineralizer waste delivered to the 100,000-gal demineralizer waste neutralization tank. The residue from the demineralizer waste neutralization tank will be piped to the evaporation ponds for disposal. Concentrated acid stored in the acid storage tank will be diluted in a mixing tee with condensate to attain the desired acid concentration for primary and secondary cation regeneration. Caustic will be diluted in a similar manner using warmed condensate. Condensate will be prewarmed in a caustic dilution water heater to make it more effective and to ensure a homogeneous dilution of the caustic which will then be used to regenerate the primary and secondary anion exchangers.

SECTION 35.0

INDUSTRIAL WASTEWATER COLLECTION SYSTEM AND OIL SKIMMING AND DRAINAGE SYSTEM

35.1 INDUSTRIAL WASTEWATER COLLECTION SYSTEM

Maximum reuse and recovery of wastewater is planned to minimize water use. Depending on the waste properties, all plant industrial wastewater will be either recovered for reuse, treated by local oil removal equipment and recovered, or pumped to the evaporation ponds.

The industrial wastewater collection system for each unit will include a main waste pump, condenser pit sumps, boiler area sumps, and air preheater, stack, and scrubber area sumps with collection piping, pumps, and controls to collect and dispose of wastewaters arising from normal maintenance and start-up operations. Two additional sumps with piping, pumps, and controls will be provided in the plant water treatment area and the warehouse and shops area.

35.1.1 MAIN WASTE SUMP

The main waste sump will receive wastewaters from the turbine building condenser pit sumps, boiler area sumps, and air preheater, stack and scrubber area sumps. In addition the Unit 1 main waste sump will receive wastewater from the warehouse and shops sump. The main waste sump will include an oil separator compartment and a wastewater compartment. Clarified water from the oil separator compartment will be discharged to the wastewater compartment. Two 15,000 gpm, 50 ft TDH sump pumps per unit will normally discharge clarified wastewater from the main waste sump to the pug mills described in Section 12.3. Excess wastewater will be discharged to the evaporation ponds.

35.1.2 WATER TREATMENT AREA SUMP

Makeup softener filter system drains, circulating water chemical system drains, boiler feed makeup softener system drains, feedwater chemical systems drains, and area washing drains will be collected in the water treatment area sump. Two 300-gpm sump pumps will discharge this wastewater to the demineralizer water utilization tank described in Section 34.8.

35.1.3 WAREHOUSE AND SHOPS SUMP

The warehouse and shop sump will collect wastewaters from the area wash down operations and miscellaneous drains. Two 125 gpm, 50 ft TDH sump pumps will discharge to the Unit 1 main waste sump.

35.1.4 CONDENSER PIT SUMP

There will be one condenser pit sump with two sump pumps for each unit. One 250 gpm, 70 ft TDH sump pump will be provided for flows from area wash down, feedwater heater, cooling water, and other miscellaneous drains. One 1000 gpm, 70 ft TDH sump pump will be provided for flows coming from condenser shell or tube side drains. This wastewater will be discharged to the main waste sump.

35.1.5 BOILER AREA SUMP

There will be one boiler area sump and three sump pumps for each unit. One 150-gpm, 60 ft TDH pump will be provided for flows resulting from area wash operations and flows from miscellaneous drains. Two 1000-gpm, 60 ft TDH pumps will be provided for wastewater from boiler washing, rain runoff, boiler tube acid cleaning, and flue gas recirculation fan washing. These wastewaters will be pumped from the boiler area sump to the main waste sump.

35.1.6 AIR PREHEATER, STACK, AND SCRUBBER AREA SUMP

There will be one sump and three sump pumps for each unit. One 250-gpm, 70 ft TDH pump will be provided for area wash operations and light rain. Two 1500-gpm, 70 ft TDH pumps will be provided for wastewaters from air preheater washing, stack washing, wastewater from miscellaneous equipment, and heavy rain. These wastewaters will be pumped to the main waste sump.

35.2 OIL SKIMMING AND DRAINAGE SYSTEM

The purpose of the oil skimming and drainage system is to collect industrial wastewater containing oil and to process and clarify the oil-water mixture so that the water is cleaned for reuse.

The oil skimming and drainage system will include an oily waste collection system and a contaminated water sump for each unit and one oil-water separator for each pair of units. The oily waste collection system consists of drains from equipment bedplates, lube oil reservoirs, and various other areas which discharge to the contaminated water sump. One 75-gpm, 70 ft TDH contaminated water sump pump will discharge the oil wastes through a common header for all four units to two 150-gpm oil-water separators. The clarified water from the separators will be treated in an excelsior filled oil observation tank before discharge to the evaporation ponds. Oil collected in the separators will be trucked from the site to an approved disposal site.

SECTION 36.0

CONTROL AND INSTRUMENTATION SYSTEM

This section describes the control and monitoring systems and related control rooms, panels, etc., that apply to the boiler, turbine, and auxiliary control systems. Specific monitoring systems for air emissions control and related environmental requirements are described in Section 10.0.

Centralized control and monitoring systems will be provided to optimize operation and station manning. All major equipment required to be operator controlled will be controlled from either the central control room or from local control boards.

Control systems will be provided wherever practical to automatically bridge the various plant operating modes so as to reduce manual intervention. Monitoring systems will include conditional alarms to minimize false or nuisance type indications. The control systems and equipment provide high availability and reliable service.

A computer system will be provided for each unit capable of data acquisition, alarm monitoring, information logging, performance calculation, and automatic turbine start-up (ATS).

36.1 CENTRAL CONTROL ROOM

One common control room, as shown in Figure B6 and B15, will be used for each pair of units. Each control room will include instrumentation to indicate equipment status and process variables necessary for automatic and manual operations. Plant equipment common to all four units will be monitored or controlled from the control room for Units 1 and 2.

Each control room will contain a boiler-turbine-generator (BTG) control bench, as shown in Figure B39, and an operator's desk and auxiliary control board, as shown in Figure B40. The BTG and auxiliary boards will be approximately 7 ft in height.

The BTG board for each pair of units will contain controls and instrumentation for controlling equipment directly related to each BTG unit. The controls and instrumentation will include boiler control system manual/automatic (M/A) selector stations, burner-pulverizer system control panels, main turbine electo-hydraulic-control (EHC) panels, television monitors for furnace viewing, computer system input and output equipment, controls for major unit axuiliary equipment, indicators and recorders for process variables, and station annunciator windows. The computer system equipment will include a cathode-ray tube (CRT), a typewriter, and high speed printers.

The auxiliary control panel will contain controls and a graphic display of the switchyard electrical system, controls for major equipment common to both units, the turbine supervisory instruments, and station annunciator windows.

The operator's desk will contain computer controls and displays for operator aids, an intercom, and the telephone system controls. There will be no plant equipment controls located on the operator's desk.

Adjacent to the control room will be a shift supervisor's office, a chart room, a kitchen, lavatory facilities for men and women, a chemical laboratory complete with chemical control board, a test engineer's and conference room, and a computer room. All of these rooms will be air-conditioned.

36.2 LOCAL CONTROL PANELS

Controls for auxiliary systems that do not normally require the immediate attention of the control room operator and that can be supplied as a complete system will be mounted on control panels located in the general vicinity of the controlled equipment. All instrumentation and control equipment located on these local panels will function under local environmental conditions. Local control panels will be provided for the following systems:

1. Industrial water supply pumps
2. Primary water treatment
3. Generator hydrogen and stator cooling water
4. Furnace bottom ash removal
5. Fly ash removal
6. Ash unloading
7. Coal handling
8. Auxiliary boilers
9. Air compressor
10. Chemical feed equipment (in Chemical Laboratory)
11. Train unloading

12. Auxiliary condensate demineralizer
13. Sodium zeolite softener

These control systems will include annunciation either in the main control room and/or on the local control panel.

36.3 CONTROL SYSTEM CABINETS

Relay and solid-state logic component cabinets for the major control systems and the air relay racks for the auxiliary pneumatic control loops will be located in the control equipment terminal room as shown in Figure B15. The cabinets will contain sufficient instrumentation to maintain, diagnose trouble, and calibrate the control logic modules. These control systems cabinets include:

1. Boiler-turbine controls
2. Burner-pulverizer controls
3. Turbine controls
4. Turbine supervisory instruments
5. Data monitoring
6. Annunicator
7. Boiler flame scanner control
8. Control relays
9. Unit protection

36.4 MAJOR CONTROL SYSTEMS

The plant control and monitoring systems will maintain safe, reliable, and economic generation under all operating conditions. Redundant control loops or components will be provided in the automatic control and interlock systems that are critical for safe shutdown. Standby equipment will be put into service automatically wherever practicable to maintain continuity of service. Selection of electric and/or pneumatic devices will be based on their reliability, flexiblity, compactness, responsiveness, and economics.

36.4.1 BOILER-TURBINE CONTROL SYSTEM

The boiler-turbine control (BTC) system will be the primary control of the unit power generation. The BTC system will integrate the boiler-turbine start-up controls, the boiler-turbine load controls, and the burner-pulverizer control logic systems so as to provide smooth operation from start-up to full load. The system will receive a load demand signal either locally from the control operator via a unit control master panel or remotely from a central load dispatching center via wire or telemetering equipment. This load demand signal will limit the input and output power of the generating unit should some limiting condition exist within the boiler or its auxiliaries. In either mode the operator can set a high and low limit for the unit generation and a maximum rate of load change.

The BTC system will be an analog and digital electronic control system integrating the boiler and turbine control loops using feed forward control techniques to control the turbine and boiler inputs. The electric analog system will bridge operating modes where feasible to reduce manual operation.

36.4.2 BOILER CONTROLS

The boiler control system will be a fully automatic system which receives a master demand signal, generated in the unit control master panel, to ensure that the boiler feedwater, fuel, and air are properly coordinated to match the requirements of the turbine generator. All primary boiler inputs will be controlled on a feed forward basis.

The control system will have a unit load control loop which will reduce the boiler master demand as necessary based upon boiler conditions and the state of the boiler auxiliaries such as the forced draft fans, induced draft fans, and boiler feed pumps. The control of boiler inputs will be interlocked to prevent the air-flow demand from dropping below the measured fuel flow and to prevent the fuel demand from increasing above the measured air flow.

All M/A selector stations and instrumentation required for M/A control of each boiler variable will be mounted on the unit BTG board in the central control room.

Controlled variables will be moduled with pneumatic operators wherever practical for economical and reliability purposes, and will be modulated through the use of current-to-pneumatic transducers.

36.4.3 TURBINE CONTROL SYSTEM

The turbine control system will be a standard EHC system which makes use of solid-state components and integrated circuitry to regulate the speed and loading of the turbine. The turbine control system will include all required controls for ATS and emergency shutdown.

During normal operation, the turbine control system will follow the load demand signals from the boiler analog controls. When the turbine controls act to limit the turbine load, interlocks will limit the boiler control system to follow the turbine load and maintain proper steam conditions.

A complete set of turbine supervisory instruments will be provided with the main turbine to allow monitoring of start-up, shutdown, and normal turbine operation.

A remote operating panel mounted on the BTG board will be equipped with switches, indicators, and indication lights for remote operation of the turbine. An additional remote test subpanel, also mounted on the BTG board, will be provided with all test and indication devices to remotely test the operation of the turbine control, stop and intercept valves, and the various turbine trip circuits.

ATS will be provided either by the turbine EHC or by the unit computer. Under ATS, the EHC will receive initiating control commands for selecting optimum speeds, acceleration rates, and hold times to optimize the start-up time. ATS supervision will allow automatic turbine operation from turning gear to unit synchronization and minimum load, by initiating action of automatic subloop controls. The operator will have the capability of overriding the ATS at any time during start-up and continuing the start-up manually.

36.4.4 BURNER-PULVERIZER CONTROL SYSTEM

The burner-pulverizer control system will interlock the controls of the primary air dampers, pulverizers, feeders, ignitors, and warm-up guns for start-up and shutdown operation. A flame scanning system will continuously monitor the coal, ignitor, and warm-up gun flames. A separate unit protective tripping logic will be integrated with the burner-pulverizer control system to ensure complete, safe shutdown during either a boiler-turbine or generator-initiated trip.

The burner-pulverizer and BTC systems will trip the boiler fires in the event of an electrical separation of the generator from the external systems. In the event of a station blackout, safe unit shutdown power for the controls will be provided from the station battery system in addition to a pneumatic backup.

A properly supervised start-up and shutdown sequence for each pulverizer and its associated equipment will be provided. Each sequence will be initiated by the operator from the main burner-pulverizer control panel on the unit BTG board.

The burner-pulverizer logic control system equipment will be of the solid-state electronic type. System control switches will be preassembled and tested in subpanels for mounting in the unit BTG board.

36.4.5 UNIT PROTECTION SYSTEM

Plant equipment will be protected from excessive damage to maintain power system stability and to minimize personnel exposure to possible electric shock.

Protective circuits, including sensors and trip circuits, will be independent of control, monitoring, and metering circuits whenever practicable. Duplicate protective schemes, to increase reliability, will be used on all major equipment whenever practicable. This will permit maintenance, or removal from service for test, of protective equipment without interruption of the power system. The duplicate circuits will be separate electrically and physically whenever practical to increase system reliability. Front mounted blocking switches will be provided to block each individual protective function. All blocking switches will be enclosed in glass covers. An output from all major protective functions will be provided to the unit annunciator or event recorder. Protective circuit d-c branches will be protected with independent circuit breakers. Solid-state equipment will be supplied from dedicated 48 volt d-c power supplies to provide isolation and minimize surges which might damage solid-state devices.

Each unit will be protected with generator protection relays, unit transformer protection relays, and auxiliary supply transformer protection relays. Station service transformers, step down transformers and high voltage buses will be provided with independent overlapping protective zones. All high voltage circuit breakers will be equipped with breaker failure relays.

36.4.6 COAL HANDLING CONTROL SYSTEM

The coal handling control system will control the transport of coal from the train unloading facility to the boiler coal silos which feed the individual coal pulverizers. The system will include sampling, dust collection and dust suppression equipment, weigh scales, metering instruments, and all controls required for proper control and operation.

The control and operation of the coal handling system will be regulated from a control panel located in the coal yard control building as shown in Figure B1 and B19. The control panel will contain the necessary control stations for initiating semiautomatic and remote manual control of each portion of the coal handling system.

The coal handling system will be continuously monitored and all abnormal conditions will be annunicated on the coal yard local control panel. Abnormal conditions will also be alarmed in the Units 1 and 2 control room on the sequence of events recorder.

36.4.7 ASH HANDLING CONTROL SYSTEM

The ash handling control system will control the removal of the bottom and economizer ash from the boiler, the mill rejects from the coal mills, and the fly ash from the electrostatic precipitator hoppers, and will control the transportation of these materials to holding containers where they will be stored and prepared in a condition suitable for truck disposal. Ash will be removed from all hoppers during each shift.

The control system will automatically sequence through all furnace hoppers for each unit on a timed basis upon initiation of the system by the operator. Manual selection will enable any particular hopper to be selected for continuous operation.

Fly ash removal and transport to the fly ash silo will be by a pressurized pneumatic system. Individual hoppers may be bypassed or individual rows of hoppers may be selected for continuous ash removal during special operating conditions.

Control panels for the ash handling system will be located in weathertight cubicles near the controlled equipment. System status and critical alarms will be indicated on the auxiliary annunciator panel.

36.4.8 AUXILIARY BOILER CONTROLS

The control system for the two plant auxiliary boilers will be preassembled on a common local control panel located adjacent to the boilers. The control system will also incorporate interlock and control equipment for soot blowers, pumps, and the auxiliary deaerator. An annunciator on the local panel will indicate abnormal boiler conditions and also indicate a trouble alarm on the auxiliary bay panel annunicator. The Unit 1 event recorder will also monitor and alarm auxiliary boiler abnormalities.

The control system will include combustion and feedwater controls, a burner control, and a flame safety system. These systems will be fully automatic and fail-safe under all operating conditions. The controls will provide full automatic operation from hot start-up to full design steam flow. The control system will be a pneumatic system. The burner control and flame safety system will comply with all applicable requirements of the National Fire Protection Association (NFPA).

36.5 AUXILIARY CONTROL SYSTEMS

Automatic control systems are required on certain plant equipment which are not included in the major control systems previously described. These control systems are divided into pneumatic analog controls and electrical on-off controls.

36.5.1 PNEUMATIC CONTROL SYSTEMS

In general, all pneumatic controls will be mounted locally near the controlled equipment except for those instruments which are critical to plant operation or which require considerable operator attention. For reason of economy and reliability, these controls consist of pneumatic type control equipment. Typical examples of pneumatic control systems are:

1. Feedwater heater level control
2. Condenser hotwell level control
3. Evaporator controls
4. Auxiliary steam regulators
5. Pump minimum flow controls
6. Station makeup water controls

36.5.2 ELECTRICAL EQUIPMENT

Major electrical auxiliary equipment will have control switches located in the main unit control room. These control switches will have START-AUTO-STOP-STANDBY positions and motor starter breaker-position indicating lights. Local controls will be provided for motor operators that have adjustable contacts for control or interlock.

Auxiliary equipment that is normally in continuous operation or used only for maintenance will be controlled from local control stations only. Annunciation of abnormal conditions or equipment failure will be provided in the main control room.

Automatic synchronizing equipment will be provided for the main generator with provision for manual control from the main control room.

The unit auxiliary bus will provide a fast automatic transfer to the station service bus in the event of a unit trip to minimize the voltage interruption to plant auxiliary equipment.

36.5.3 OFF-SITE WATER PUMPS

All off-site water pumps will have provisions for local and remote operations. A plant equipment operator will operate and monitor these pumps from a remote control panel in the control house situated adjacent to the ground and surface water storage tanks. Local controls will be located in the pump house of each set of pumps.

36.5.3.1 FREMONT RIVER PUMPING PLANT

The pumps at the Fremont River pumping plant will automatically pump available river water to the reservoir. These pumps will automatically and sequentially start and stop at preset river levels. The three tainter gates will be provided with automatic emergency high level controls for opening of gates under these conditions. Manual resetting will be required for any tainter gate opening under emergency condition.

A stream gage will be installed approximately 1 mile upstream of the Fremont River diversion dam for anticipation of sediments due to flooding conditions. This input will be used to remotely close the inlet gate to the pump suction bay.

Information such as river level, pumps in service, and abnormal conditions at the pumping plant will be alarmed in the pumping plant control room and at the generating station.

Controls will be provided to automatically shutdown any pump and alarm the operator whenever abnormal conditions occur. Instrumentation will be provided to totalize the flow pumped to the reservoir.

36.5.3.2 RESERVOIR PUMPING PLANT

The pumps at the reservoir pumping plant will automatically pump water to meet the requirement of the generating plant. Flow signals from venturi flowmeters on the pumps' discharge lines will sequentially start and stop the pumps as flow demand increases or decreases.

Reservoir level, flow rate, and totalized flow leaving the pumping plant will be recorded in the pumping plant control room. Flow rate and totalized flow at the generating station will be monitored and compared for difference to determine trouble along the pipeline. Abnormal conditions will be annunciated in both the reservoir pumping plant and at the generating station.

Controls will be provided to automatically shutdown any pump and alarm the operator whenever abnormal conditions occur.

36.5.3.3 GROUNDWATER WELL FIELD

The string of approximately 20 well pumps will be remotely operated and selected by desired groups and/or from desired areas. The basic control scheme will be to operate the required number of well pumps to provide a base water supply to the generating plant. The reservoir pumps will then supply the difference between this base water supply and the generating plant water demand.

Critical points on all pumps will be monitored and any abnormal condition will be alarmed in both the local control panel and the main control room.

36.5.4 WATER TREATMENT CONTROLS

Water treatment controls will be provided for the boiler feed water, condensate, and circulating water systems. Control instrumentation is indicated in Figures B45 and B46. All instruments will be located on a control board in the chemical laboratory.

The chemical laboratory will include connections to sample and instruments to monitor pH, conductivity, dissolved oxygen, and turbidity levels at various locations in the feedwater and condensate streams.

The evaporators effluent will be monitored and controlled so that the effluent will either be dumped to waste or added to the feedwater heater drain flow. Evaporator blowdown flow will also be monitored and controlled.

Circulating water will be chlorinated and acid-treated, and monitored for pH and chlorine level. Blowdown from the circulating water system will be controlled from the chemical laboratory based upon the conductivity of the circulating water.

36.5.5 TEST INSTRUMENTATION FACILITY

A test instrumentation facility will be located in the instrument repair shop as shown in Figure B14. This facility will be used for calibrating the high accuracy unit performance testing transducers and the conventional operating instrumentation.

36.6 MONITORING SYSTEM

The monitoring system will be composed of data input to, and output from the computer system for each unit. The system will feature unit start-up and shutdown monitoring, equipment performance calculations, and routine station logging.

36.6.1 ANNUNCIATOR SYSTEM

An annunciator system will be provided to give trouble information with visible and audible indication in the main unit control room, chemical laboratory, and auxiliary bay. The annunciator will serve as a backup alarm monitor to the events recorder. Those points which require immediate operator attention to avoid serious effect on unit generation will be shown on the annunciator windows. The annunicator windows will be arranged logically and include critical information. Annunciator alarms will also be indicated on the sequence-of-events printer to provide a time log of station trouble. Alarm points may also be displayed on the CRT on demand by the operator.

The annunciator will be of the illuminated-window type. The system logic will be of the solid-state type, suitable for use on the 125-volt d-c station battery. Repeating alarm chime and silencing, resetting, and testing pushbuttons will be located on the BTG board, auxiliary board, and operator's desk.

Each alarm point will be indicated on an individual window on the local panel. A single general alarm window on the main control room auxiliary control panel will annunciate the system in which an alarm exists. These local annunciators will be located on each of the local control panels listed in Section 36.2 above.

36.6.2 COMPUTER SYSTEM

A computer system for each unit will be provided to scan various plant parameters, log information, annunciate off-normal conditions, assist the operator, provide monitoring of the river, off-site water pumps, make performance calculations, and for monitoring and initiating control of the turbine-generator during plant start-up.

The following logs will be prepared by the computer system:

1. Periodic plant logs
2. Special purpose logs
3. Post trip review
4. Sequence-of-events log
5. Special turbine logs

The computer system will include operator aid programs to allow the operator to use the computer to present plant information in the most useful format. This information will be indicated either on CRT's or recorded on trend recorders or high speed printers.

The following performance calculations will be performed by the computer:

1. Unit net heat rate
2. Boiler efficiency
3. Turbine-generator cycle heat rate
4. High pressure turbine efficiency
5. Intermediate pressure turbine efficiency
6. Air preheater performance
7. Feedwater heater performance
8. Condenser performance
9. Stack effluent

The following computer driven display devices will be located in the main control room:

1. Plant operator's desk with a 14-in. CRT and keyboard.
2. Utility typewriter.
3. Data logging high speed printer.
4. Sequence-of-events printer.
5. Alarm CRT (19-in. 4 color).
6. General purpose CRT (19-in. 4 color).

A study will be made during detailed design to determine the degree of computerization which will be economically justified.

36.6.3 AUTOMATIC OSCILLOGRAPH

An automatic oscillograph will monitor generator unit and power system currents and voltages. It will also monitor protective relay functions and circuit breaker position.

The oscillograph will be equipped to start automatically on abnormal generator and power system conditions. It will give an indication of time, date, and station identification for each oscillograph record. One oscillograph will be provided for each unit. Power for the oscillograph will be furnished by the station d-c system and will be independently fused.

36.6.4 LOAD FREQUENCY CONTROL

It is expected that the plant will operate as a base load facility for the initial years of operation and load following will not be required. Load frequency control equipment, therefore, will not be installed. Provision will be made for the future installation of Project participants' equipment.

SECTION 37.0

SWITCHYARD

The switchyard, located as shown in Figure B1, will receive energy from each of the four main generators at 345 kv after being transformed from 26 kv by the main transformers. Outgoing energy will be transmitted by four 345-kv transmission lines to the IPP converter station and by two 345-kv transmission lines to the Utah participants. The IPP converter station is described in detail in Volume III.

A 69-kv switchrack will receive energy from the 345-kv switchrack through two 345/69-kv bus banks. This 69-kv switchrack will furnish energy to the plant auxiliary equipment through two underground 69-kv lines. The 69-kv switchrack will furnish energy to the water pumping plants and well fields through three 69-kv overhead lines and in addition will furnish energy to Garkane Power Association and the IPP Converter Station through 69-kv overhead lines.

37.1 345-KV SWITCHRACK

An equipment layout of the switchyard is shown in Figure D1. A one-line diagram of the switchyard is shown in Figure D2.

The 345-kv a-c switchrack will consist of a six-bay rack of breaker and one-half design equipped with power circuit breakers (PCB). The switchrack will provide for four incoming feeds from the generating unit transformers, four ties to the d-c converter station, and two outgoing transmission lines terminating on 108-ft high structures. Two 345/69-kv autotransformers will be installed as bus banks between the 345- and 69-kv racks to provide energy to the 69-kv switchrack. Each bus bank will be made up of three single-phase transformers to form a bank. One spare single-phase transformer connected to a jack bus will be installed for both bus banks.

One outgoing 345-kv a-c transmission line will connect IPP with UPL's Emery Power Plant, and the other 345-kv a-c transmission line will tie to UPL's system at the proposed Otter Switching Station and to the Paragonah Substation on the California Pacific Utilities system.

A switchyard control building will be constructed and equipped with control and relaying equipment. A communication room will be included to house microwave terminal equipment.

Common facilities for the station will include the d-c and a-c station services, yard lighting, and supervisory equipment.

37.2 69-KV SWITCHRACK

The 69-kv switchrack will receive energy from the 345-kv switchrack through two bus banks each made up of three single-phase 345/69-kv transformers. A spare transformer will be connected to a jack bus to permit replacement of a faulty unit in either bus bank. The 69-kv section of the switchyard will be a breaker and one-half arrangement utilizing oil circuit breakers. There will be positions for three 69-kv lines to provide auxiliary power to the water pumping plants and well fields remote from the plant, two underground circuits to provide auxiliary power to the plant, and two underground circuits to provide auxiliary power to the converter station. In addition one 69-kv position to provide a connection with Garkane Power Association will be included.

SECTION 38.0

MAIN TRANSFORMERS

Three single-phase transformers, as shown in Figure B2, will be provided for each unit. These transformers will increase the generated voltage to 345 kv. One single-phase spare transformer will be provided for the four units.

38.1 RATINGS

The main transformers will have a nominal voltage rating of 345 gnd Y/199-26 kv at a frequency of 60 Hz. The transformers will be forced-oil-air cooled (FOA) and will have a rated capacity of 271.5/304 Mva, 55/65C temperature rise at an altitude of 5000 ft. The transformers will be connected for grounded-wye operation of the high voltage windings and for delta operation of the low voltage windings. The generator voltage rating is expected to be in the 24- to 26-kv range. For this study a 26-kv voltage rating has been assumed.

38.2 ADDITIONAL CHARACTERISTICS

The bil of the transformer high voltage windings will be 1175 kv at the line end and 200 kv at the neutral end. The low voltage windings bil will be 150 kv. Conventional no-load taps will be provided in the neutral ends of the high voltage windings.

Pedestal type surge arresters will be provided to limit voltage surges caused by lightning or switching operations to acceptable values. Normal accessories required for transformer protective and alarm functions will be provided. These will be wired to terminal cabinets for external connection.

The transformer oil preservation system will be a diaphram-conservator type. Oil to air heat exchangers, fans, and pumps will be provided to limit the transformer temperature rise to acceptable values. With one-half the cooling equipment out of service, the transformers will have a continuous output rating of not less than two-thirds rated capacity. Two separate sources of auxiliary power will be provided for the fan and pump motors. Manually operated, mechanically interlocked circuit breakers will be provided to enable switching between the normal and emergency sources.

SECTION 39.0

SUBSYNCHRONOUS RESONANCE EQUIPMENT

Subsynchronous resonance equipment will not be required since the d-c Southern California transmission system alternative has been selected.

SECTION 40.0

CLASSIFICATION OF HAZARDOUS AREAS

The classification of hazardous atmospheres will be in accordance with the latest edition of the National Electrical Code (NEC). Each room, section, or area will be individually evaluated to ensure that the proper equipment, devices, and associated wiring is selected for that particular location. Wherever possible electrical equipment will be located in less hazardous or in non-hazardous areas.

40.1 FLAMMABLE GASES AND VAPORS

Areas in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures are Class I locations. Class I locations may include fuel oil unloading and storage areas; lubricating oil storage and processing areas; vehicle service and fueling areas; paint spray and storage area; chemical sampling cabinets; and plant waste sumps. Specific areas around the boiler front and adjacent to generator hydrogen cooling equipment may also be classified as Class I areas.

40.2 COMBUSTIBLE DUST

Areas in which combustible dust may be suspended in the air in quantities sufficient to produce explosive or ignitable mixtures are Class II locations. Class II locations may include coal fuel unloading areas, transfer, and storage areas; belt conveyor systems; and coal pulverizer and boiler front areas.

40.3 ELECTRICAL EQUIPMENT

Electrical equipment installed in these areas must, in most cases, be of special construction to prevent explosion or fire caused by electrical arcs or elevated temperature. Electrical equipment and devices installed in these areas will generally be in accordance with the applicable requirements of the NEC.

SECTION 41.0

METAL ENCLOSED BUS

Metal enclosed isolated phase bus, as shown in Figure B3, will be used to connect the generator terminals to the main and unit auxiliaries transformers. Metal enclosed cable bus will be used to connect the 13.8-kv side of the station service and unit auxiliaries transformers to their respective 13.8-kv switchgear. Bus-tie connections between various 13.8-kv switchgear, and connections between 13.8-kv switchgear and the 13.8-4.16 kv boiler auxiliaries transformers will also be made with metal enclosed cable bus.

41.1 ISOLATED PHASE BUS

The isolated phase bus will be all welded, aluminum enclosure, aluminum conductor, and low flux type. The three-phase portion of the isolated phase bus between the generator and the main transformer will be forced-air-cooled; be rated at 21,000 amp continuous, 300,000 amp momentary; and have a bil of 150 kv. The single-phase taps to the single-phase main transformers will be self-cooled; be rated at 12,000 amp continuous, 300,000 amp momentary; and have a bil of 150 kv. The three-phase taps to the unit auxiliaries transformers will be self-cooled; be rated at 1200 amp continuous, 500,000 amp momentary; and have a bil of 150 kv.

Included with the isolated phase bus will be generator and transformer terminations; generator neutral grounding equipment consisting of a neutral termination compartment with distribution transformer and secondary resistor; and potential and surge equipment consisting of an enclosure with six potential transformers and three sets of surge arrestors and capacitors.

The cooling equipment for the forced-air-cooled portion of the isolated phase bus will consist of a 100 percent capacity air-to-water heat exchanger and two independent full capacity main and standby blowers. The bus unit will be capable of full-rated continuous operation without cooling water by dual operation of both the main and standby blowers. Changeover from main to standby blower or dual blower operation will be done manually. Alarms will be furnished for loss of air flow, loss of water flow, and high temperature. An electric heater will be provided to maintain the temperature of the bus conductor and enclosure above the dew point temperature during generator shut-down periods.

41.2 CABLE BUS

The cable bus will consist of single conductor insulated power cables as described in Section 48.0. The cables will be held in place by insulated blocks to maintain a cable spacing of about 3 in. Each phase will consist of two or more cables connected in parallel. The complete assembly will be enclosed in a ventilated aluminum enclosure.

The connections between the unit transformers, the station service transformers and their respective 13.8-kv switchgear, and the bus-tie connections will consist of four 1000-kcmil cables per phase and will be rated 3000 amp, 15 kv. The connections between the 13.8-kv switchgear and the 13.8-4.16 kv transformers will consist of two 750-kcmil cables per phase and will be rated 1200 amp, 15 kv.

SECTION 42.0

AUXILIARIES POWER SYSTEMS

The auxiliaries power systems are shown on the Basic One Line Wiring Diagram, Figure C1. This system will provide normal power supply to the unit auxiliaries from 26-13.8 kv unit auxiliaries transformers and will supply station auxiliaries from 69-13.8 kv station service transformers. The station service transformers will also supply the unit auxiliaries during unit start-up or when a 26-13.8 kv unit auxiliaries transformer is out of service. Off-plant loads associated with the water supply system and coal handling facilities will be supplied by 69-kv transmission lines from the 69-kv switchrack. The power supply to the water supply system is described in Section 6.4.

Three voltage levels for the auxiliaries power systems will be utilized within the plant. These will be 13.8 kv, 4.16 kv, and 480 volt. Primary distribution of power within the plant will be at the 13.8-kv voltage level. The auxiliaries power system will be divided into two systems, A and B, at all voltage levels. Each 4.16-kv and 480-volt bus will normally be supplied from one system, but during a feeder or transformer outage, the bus can be supplied from the other system. A description of the auxiliaries power system equipment is contained in Section 44.0.

The estimated auxiliaries power system running loads are as follows:

1. Unit auxiliaries, for each unit - 64 Mva
2. Station auxiliaries at plant - 16 Mva

The loads may vary considerably with final selection of boiler and environmental protection equipment. For this study the auxiliaries transformer ratings are based on these loads.

42.1 STATION AUXILIARIES POWER SYSTEM

Station auxiliaries loads at the plant will be supplied from the 4.16-kv and 480-volt station auxiliaries power systems. The 13.8-kv system will be supplied from 69-13.8 kv station service transformers and will provide power to the 4.16-kv systems through 13.8-4.16 kv station auxiliaries transformers. The station auxiliaries transformers will also provide start-up and emergency power to the unit auxiliaries systems through 13.8-kv bus tie cables. The 480-volt system will be supplied from double ended 4160-480 volt load centers.

42.1.1 13.8-KV SYSTEM

Supply to the station auxiliaries 13.8-kv system will be through two three-phase 69-13.8 kv station service transformers rated 60/80 Mva, OA/FA 55C rise at an altitude of 5000 ft. The transformers will be wye connected on the high and low sides with a delta tertiary. Each transformer will be sized to supply the full unit auxiliaries load for one unit plus the full station auxiliaries load.

During an outage of all normal 69-13.8 kv supply to the station auxiliaries system the plant station auxiliaries loads can be back-fed from the 26-13.8 kv unit auxiliaries transformers over the 13.8-kv bus tie cables.

The station auxiliaries 13.8-kv system will supply four 13.8-4.16 kv station auxiliaries transformers, a 13.8-kv line to a well pumping field and microwave facility located near the plant site, and power to the unit auxiliaries 13.8-kv system during unit start-up, and/or when a 26-13.8 kv unit auxiliaries transformer is not available.

The switchgear will be arranged into four sections. Each section will contain positions for feeds from the 69-13.8 kv station service transformers, for bus tie cables and for feeders to 13.8-4.16 kv station auxiliaries transformers, and for the line feeding the local well field and microwave facility.

42.1.2 4.16-KV SYSTEM

The station auxiliaries 4.16-kv system will supply the following:

1. 13 coal conveyor motors
2. 2 coal crusher motors
3. 6 industrial water pump motors
4. 2 coal handling 4160-480 volt transformers
5. 2 coal supply 4160-480 volt transformers
6. 8 common facility 4160-480 volt transformers

The loads will be supplied from two 4.16-kv busses located in the main plant and two 4.16-kv busses located in the coal handling control house. The busses will be arranged in pairs with each of the two busses normally supplied from a different 13.8-kv bus.

Each 4.16-kv bus will be supplied from a three-phase 13.8-4.16 kv transformer rated 10 Mva, OA 55C rise, 5000 ft altitude. The transformers will be delta connected on the high side and resistance grounded wye connected on the low side. Each transformer will be sized to supply the load on two 4.16-kv busses during an outage of its associated 13.8-4.16 kv transformer.

The switchgear will be arranged in four sections. Each section will contain positions for feeds from the 13.8-4.16 kv station auxiliaries transformers and for feeders for 4000-volt motors and 4160-480 volt transformers.

42.1.3 480-VOLT SYSTEM

The 480-volt station auxiliaries system will supply individual station loads not exceeding 250 hp or 250 kva. The system will be a spot secondary selective arrangement utilizing six double ended load centers each equipped with a normally open bus sectionalizing breaker. The load centers will be fed from the 4.16-kv station auxiliaries power system. Load control centers will be utilized for start, stop, and reversing control of motors and valve operators rated 50 hp or less.

42.2 UNIT AUXILIARIES POWER SYSTEM

The motor-driven auxiliaries for each unit will be supplied from 13.8-kv, 4.16-kv, and 480-volt unit auxiliaries systems for that unit. The 13.8-kv system will normally be supplied from the 26-13.8 kv unit auxiliaries transformers but can be supplied by bus ties from the 69-13.8 kv station service transformers when a generating unit is not in operation. The 4.16-kv systems will be supplied from the 13.8-kv system through 13.8-4.16 kv transformers. The 480-volt systems will be supplied from double ended 4160-480 volt load centers.

Boiler feed pumps and induced draft fans will be driven by steam turbines.

42.2.1 13.8-KV SYSTEM

The unit auxiliaries 13.8-kv system for each unit will supply six 13.8-4.16 kv unit auxiliaries transformers, two forced draft fan motors, and one soot blowing air compressor motor. The loads will be supplied from two 13.8-kv busses located in the main plant.

Each 13.8-kv bus will be supplied from a three-phase 26-13.8 kv transformer rated 36/48 Mva, OA/FA 55C rise, 5000 ft altitude. The transformers will be delta-connected on the high side and resistance grounded wye connected on the low side. Each transformer will supply the normal unit auxiliaries load on its system (i.e. the A System) and one of the following additional loads:

1. The unit auxiliaries load of one 4.16-kv bus from the other system (the B System) during an outage of a 13.8-4.16 kv unit auxiliaries transformer on the other system.

2. The normal station auxiliaries load of its system (the A System) during a complete outage of power supply from the 69-13.8 kv station service transformers.

When a 26-13.8 kv unit auxiliaries transformer is out of service, or during start-up of a unit, power will be supplied to that unit's 13.8-kv bus over 13.8-kv bus tie cables from the station auxiliaries system.

42.2.2 4.16-KV SYSTEM

The unit auxiliaries 4.16-kv system for each unit will supply the following:

1. 3 condensate pump motors
2. 3 boiler feed booster pump motors
3. 2 circulating water pump motors
4. 3 cooling water pump motors
5. 2 standby auxiliary boiler feed pump motors
6. 2 warm-up gun air compressor motors
7. 2 gas recirculation fan motors
8. 2 boiler recirculation pump motors
9. 8 coal pulverizer motors
10. 2 primary air fan motors
11. 25 scrubber slurry pump motors

12. 3 scrubber vacuum pump motors
13. 5 scrubber slurry agitator motors
14. 2 turbine bay 4160-480 volt transformers
15. 2 boiler bay 4160-480 volt transformers
16. 4 cooling tower 4160-480 volt transformers
17. 2 ash handling 4160-480 volt transformers
18. 4 precipitator 4160-480 volt transformers
19. 2 scrubber 4160-480 volt transformers

The loads will be supplied from six 4.16-kv busses. Four busses will be located in the main plant and will supply the loads associated with the turbine and boiler. Two busses will be located in the scrubber control house to supply the scrubber area loads. The busses will be arranged in pairs with each of the two busses normally supplied from different 13.8-kv busses.

Each 4.16-kv bus will be supplied from a three-phase 13.8-4.16 kv transformer, delta connected on the high side and resistance grounded wye connected on the low side. Transformers supplying the turbine and boiler bay areas will be rated 15/20 Mva, OA/FA 55C rise, 5000 ft altitude; those supplying the scrubber will be rated 10 Mva, OA 55C rise 5000 ft altitude. Each transformer will be sized to supply the loads on two 4.16-kv busses during the outage of an associated 13.8-4.16 kv transformer.

The switchgear will be arranged in six sections. Each section will contain positions for feeders from the 13.8-4.16 kv unit auxiliaries transformers and for feeders for 4000-volt motors and 4160-480 volt transformers.

42.2.3 480-VOLT SYSTEM

The 480-volt unit auxiliaries system will supply individual unit loads not exceeding 250 hp or 250 Mva. The system will be a spot secondary selective arrangement utilizing 32 double ended load centers, each equipped with a normally open bus sectionalizing breaker. The load centers will be fed from the 4.16-kv unit auxiliaries power system. Load control centers will be utilized for start, stop, and reversing control of motors and valve operators rated 50 hp or less.

SECTION 43.0

EMERGENCY POWER SYSTEM

The emergency power system, as shown in Figure C2, will supply all loads required for safe shutdown of the plant units in the event of a loss of auxiliary power and to maintain the plant in a shutdown condition until auxiliary power is restored. Provisions have not been made for start-up of a plant unit without an energized transmission line providing power from an outside generating source. The emergency power system will be composed of four major subsystems: 1) the 480-volt diesel generator emergency load centers (ELC), 2) the 480-volt emergency load control centers (ELCC), 3) the uninterruptable power systems (UPS), and 4) the d-c systems.

43.1 480-VOLT EMERGENCY DIESEL GENERATOR LOAD CENTER

One ELC will be provided for the entire plant, and it will consist of one metal enclosed drawout type switchgear assembly as described in Section 44.0. Incoming positions will be provided for the two half-size diesel generator sets each with a continuous output rating of 800 kw, 480/277 volt, three-phase, 60 Hz at a power factor of 0.8 overexcited. The diesel generator sets are further described in Section 26.0. Feeder positions will be provided for the ELCCs.

43.2 480-VOLT EMERGENCY LOAD CONTROL CENTERS

Ten ELCCs will be located at points of load concentration throughout the plant. The switchgear assemblies are described in Section 44.0. Each ELCC will normally be fed from a unit or station service 480-volt load center. Automatic transfer switches will transfer the feed to the plant ELC on loss of power from the normal 480-volt load center. Feeder positions will be provided for essential but interruptable loads required for safe shutdown of the plant. These loads will include the plant elevators, communications system, and d-c system battery chargers.

43.3 DIRECT-CURRENT SYSTEM

There will be three voltage levels in the d-c system. Each unit will be provided with a 250-volt and 125-volt d-c system. One plant 48-volt d-c system will be provided. Battery rooms will be located on the ground floor of each control bay as shown in Figure B14.

The 250-volt d-c system will provide power to the UPS and to essential loads such as emergency lube oil pumps and to turbine-generator turning gear motors. The 125-volt d-c system will provide power to unit control circuits, circuit breaker tripping and closing circuits, and to the emergency d-c lighting system described in Section 46.0. A 48-volt d-c system will provide power for the communications system.

Each unit 250- and 125-volt d-c system will be provided with separate batteries and charging equipment. Standby chargers will be provided for each pair of units. A main and standby charger will be provided for the plant 48-volt d-c system. The d-c system equipment ratings are shown in Table 43-1.

TABLE 43-1

EMERGENCY POWER SYSTEM
DIRECT-CURRENT EQUIPMENT RATINGS

System (d-c volts)	Battery amp-hr	Battery Cells	Charger (d-c amp)
250	800	120	200
125	800	60	100
48	200	24	100

43.4 UNINTERRUPTABLE POWER SYSTEMS

One UPS system will be provided for each pair of units. They will be a modified reverse static transfer type system where heavy currents are provided to clear faults should they occur on one of the UPS branch circuits. The UPS output ratings will be 25 kva, 0.8 power factor lagging, 208Y/120 volt, three-phase, 4-wire, 60 Hz.

The UPS will feed critical loads which require continuous regulated power for safe operation and shutdown of each unit. These loads will include chart drives, boiler control, burner-pulverizer, and plant computer systems.

The system will automatically transfer the loads to an alternate feed should the inverter or dc source fail. Upon return to normal conditions the load will automatically be transferred back to the inverter.

SECTION 44.0

SWITCHGEAR AND LOAD CENTER EQUIPMENT

Space will be provided within the plant for auxiliaries power system switchgear and load center equipment. The 13.8-kv switchgear will be housed in ground floor rooms located under each turbine generator as shown in Figure B2. The 4.16-kv switchgear will be in enclosed rooms located in the turbine-generator bay and the control buildings as shown in Figures B2, B3, and B5; and the scrubber and the coal storage area control buildings. The 480-volt load center and load control center equipment will be located in areas of load concentration throughout the plant.

44.1 13.8-KV SWITCHGEAR

The 13.8-kv switchgear will be metal-clad 3000 amp bus, indoor type with drawout air circuit breakers and stored energy closing devices. Circuit breakers will have a 1000 Mva interrupting capacity. Incoming and tie circuit breakers will be rated 3000 amp continuous. Feeder circuit breakers will be rated 1200 amp continuous. Incoming and tie position will be equipped with overcurrent relays. Feeder positions will be equipped with overcurrent, differential, and ground fault relays.

44.2 4.16-KV SWITCHGEAR

The 4.16-kv unit switchgear in the main plant will be metal-clad 2000 amp bus, indoor type with drawout air circuit breakers and stored energy closing devices. Circuit breakers will have a 250 Mva interrupting capacity and an 80,000 amp momentary rating. Incoming circuit breakers will be rated 2000 amp and feeder breakers will be rated 1200 amp. Incoming positions will be equipped with overcurrent relays. Feeder positions will be equipped with overcurrent and ground fault relays. Feeder positions for motors rated at 1250 hp or above will also be provided with differential relays. The scrubber and station auxiliaries switchgear will be metal-clad 1200 amp bus, 1200 amp breaker type.

44.3 480-VOLT LOAD CENTERS AND LOAD CONTROL CENTERS

The 480-volt load centers will be 600-volt class, metal-clad 1600 amp minimum bus, with drawout air circuit breakers. Incoming and feeder breakers will have an interrupting capacity of 50,000 amp. Feeder breakers will be equipped with solid state overcurrent tripping devices providing adjustable long-time overcurrent, short-time and instantaneous short-circuit protection, and ground current protection. Indoor NEMA Type 1 gasketed enclosures will be utilized wherever atmospheres permit. In other areas, enclosures will be NEMA Type 3R, outdoor, walk-in weatherproof type.

Load control centers will be composed of from three to nine vertical sections depending on the area load concentration. Each vertical section will be free standing, dead-front, dead-rear, open bottom front accessible. Indoor NEMA Type 1 gasketed enclosures will be utilized wherever atmospheres permit. In other areas, enclosures will be NEMA Type 3R, outdoor, walk-in, single sided. Horizontal and vertical busses will be copper and rated at 600 and 300 amp, respectively. The bus will have a 22,000 amp momentary rating.

Incoming circuit breakers will be 600 amp maximum molded case type with a minimum interrupting capacity of 30,000 amp. The circuit breakers for NEMA sizes 1 through 3 starters will have a minimum short circuit interrupting capacity of 22,000 rms symmetrical amperes at 480 volt. Each starter will have three-phase overload protection using electric type overloads. Each combination starter and circuit breaker unit will have pull-apart terminal block. Each starter will have START-STOP push buttons with a reset and a green light indicating OFF, and a red light indicating ON. Push buttons and lights will be an integral part of the unit and not of the door, such that combination starter and circuit breaker unit can be pulled out without wire disconnection.

SECTION 45.0

MOTORS

All motors will be across-the-line starting and capable of starting and accelerating their loads at 85 percent voltage. They will have sealed or encapsulated Class B insulation systems and be suitable for operation at an elevation of 5000 ft in the temperature and atmospheric conditions prevailing at the plant site. It was determined by economic evaluation that boiler feed pump and induced draft fans will be turbine driven. For more information about the turbine drives, refer to Sections 9.3 and 15.2.3. A preliminary listing of motor and auxiliary loads is included in Section 42.0.

45.1 RATINGS

Motors exceeding 3000 hp will have a voltage rating of 13.2 kv. Motors 3000 to 300 hp will be rated 4.0 kv. Motors 250 hp and below will be rated 460 volts. Motors of 13.2 kv and 4.0 kv ratings installed within the plant building will be open drip proof type. Those installed outdoors will be weather protected Type II. Motors rated at 460 volts will be open drip proof except that motors of 50 hp and below which are essential to plant operation or installed in exposed locations will be totally enclosed and fan cooled.

45.2 ADDITIONAL CHARACTERISTICS

Space heaters will be installed in all 13.2-kv and 4.0-kv motors and in 460-volt motors 50 hp and above which are classed for intermittent duty or are installed in exposed locations. Bearing temperature detectors will be provided for all 13.2-kv and 4.0-kv motors. Surge arresters will be installed on all 13.2-kv and on 4.0-kv motors, 1500 hp and above.

Current transformers for differential protection will be provided for all 13.2-kv motors and for all 4.0-kv motors rated 1250 hp or above. All motors will be supplied with oversize connection boxes of sufficient size to accommodate the necessary terminations and protective equipment. Separate connection boxes for power leads, thermocouples, and heaters will be supplied. Motors installed in hazardous locations will conform with the latest edition of the NEC for the area classification specified.

SECTION 46.0

LIGHTING

The lighting system will provide illumination for safe access to all plant and yard areas. Working areas will be lighted to provide maximum safety, working efficiency, and visual comfort for working personnel. No special provisions will be made for architectural enhancement of the superstructure.

46.1 LIGHTING LEVELS

The levels of illumination will be in accordance with the Illuminating Engineering Society (IES) recommendations. The lighting levels for the various areas are shown in Table 46-1.

TABLE 46-1

LIGHTING LEVELS

	Minimum Foot-Candle
Battery rooms	20
Chemical laboratory	150
Switchgear room	30 to 50
Control rooms	100
Turbine bays	30
Boiler bays	10
Burner fronts	25
Fan bays	10
Relay rooms	50
Locker rooms	50
Instrument repair shop	150
Washrooms	40
Offices	120
Yard and street lighting	0.5
Stack lighting	FAA
Maintenance shops	80 to 100
Kitchens	50
Terminal rooms	50
Chemical feed room	50

Levels not indicated above will follow the latest recommendations of IES.

46.2 LIGHTING SUPPLY

The voltages utilized for lighting in the plant will be 480/277-volt gnd Y three-phase, 120/240-volt single-phase, and 125-volt dc. Power for a-c lighting will be fed from main lighting switchboards which in turn will be fed from 480-volt station service load centers. Each generating unit will have its own complete independent lighting system for both normal and emergency lighting. Control house lighting will be fed from a separate station service power source. Normal lighting circuits in the superstructure and control house will be 277 volt, supplied from 480/277-volt lighting switchboards. Each remote facility will be lighted from a lighting panel fed from a local load center located in the area.

46.3 LUMINAIRES

Mercury vapor, fluorescent, and incandescent luminaires will be used for general lighting throughout the superstructure. Fluorescent units will be utilized in the burner front area and in areas where mounting heights are lower than 8 ft.

Turbine bay lighting will utilize high bay mercury vapor luminaires. Control house general lighting will utilize fluorescent fixtures. The control room will utilize a luminous ceiling with integral fluorescent fixtures. A minimum of three dimmer controlled zones will be provided.

Stack lighting will utilize high-intensity type lighting fixtures and be installed in accordance with FAA requirements. Facilities for relamping will be provided.

All roadway and protective boundary lighting will utilize mercury vapor street lighting luminaires and will be photocell controlled.

Lighting fixtures in locations containing hazardous atmospheres will be installed in accordance with the requirements of the NEC.

46.4 EMERGENCY LIGHTING

All emergency lighting will be incandescent and will be an integral part of the normal lighting system. It will be supplied from a 480/120-volt transformer for each unit and will automatically transfer to the station 125-volt battery on loss of ac. The emergency system will provide lighting at every doorway, stairway, ladder, platform, pit, passageway, observation port, and critical operating station. The emergency lighting system will be capable of 1/2 hr of d-c operation for all areas except the control rooms where the period will be 3 hrs.

SECTION 47.0

COMMUNICATIONS

The communications system will include a dial telephone system, a public address system, an intercom system, and a radio page system. The intraplant system will cover the main plant, yard, switchrack, and coal unloading and handling areas. Major communications equipment will be located in the Units 1 and 2 Control Bay. Communication links to the well fields, diversion works, and reservoir areas will be provided as part of the water supply supervisory control equipment described in Section 6.4. The microwave communications system is described in Volume III, Section 4.5.

47.1 TELEPHONE SYSTEM

The plant telephone system will be connected to the local telephone company's system for universal telephone service. Specific plant telephone stations, assigned to key personnel, will have direct outside dialing capability, while other stations will require plant operator assistance in placing toll calls. A 500 instrument phone system is anticipated with an additional 270 telephone jacks dispersed throughout the plant to provide communication for maintenance and test personnel. There will be a 500 line private automatic branch exchange (PABX) switchboard expandable to 800 lines.

47.2 PUBLIC ADDRESS SYSTEM

The public address system will provide paging and alarm coverage of the entire plant. The system will be capable of being accessed from any telephone within the main plant, and it will be possible to page individual major areas.

47.3 INTERCOM SYSTEM

A 12 station intercom system will link the administrative offices, service facilities, and the various control rooms together.

47.4 RADIO PAGE SYSTEM

A radio page system will be provided for operating, maintenance, and test personnel. Forty paging units and 20 two-way communication units will be provided. The paging system may be accessed from any phone.

SECTION 48.0

WIRE AND CABLE

The conductor material for all cables, sizes No. 4 American Wire Gauge (AWG) and smaller, will be copper. For cable sizes No. 2 AWG and larger, aluminum conductor material may be used if economic and technical considerations at the time of purchase dictate. For this study copper conductor material is assumed.

Flame resistance will be the major consideration when selecting cable insulation and covering for use in various areas of the plant.

Current carrying capacities will be calculated using the latest edition of the NEC. However, no conductor size will be smaller than No. 12 AWG for power circuits or No. 8 AWG for current circuits.

48.1 13.8- AND 4.16-KV CIRCUITS

The insulation class of cables used on 13.8- and 4.16-kv circuits will be 15 and 5 kv, respectively. Insulation will meet the heat, flame, and moisture resistance requirements of IEEE Standard 383. Cables smaller than 4/0 AWG will be multiconductor with cross-linked polyethylene (XLP) insulation and overall neoprene sheath. Cables 4/0 AWG and larger will be single conductor with ethylene propylene rubber (EPR) insulation and neoprene sheath. All cables will have copper tape conductor shielding. Cables routed in cable tray will have overall interlocked armor.

48.2 LOW VOLTAGE POWER AND CONTROL CIRCUITS

Insulation will meet the heat, flame, and moisture resistance requirements of IEEE Standard 383. The insulation class of all cable will be at least 600 volts. Cable smaller than 4/0 AWG will be multiconductor with XLP insulation and overall neoprene sheath. Cables 4/0 AWG and larger will be single conductor with EPR insulation and neoprene sheath.

48.3 SPECIAL USE CABLE

Communication and low-level signal cable will consist of twisted pairs, with polyethylene (PE) or polyvinyl chloride (PVC) insulation, overall shield and overall PVC jacket. For analog and pulse type circuits, individual shields will be provided for each pair. Lighting branch circuits will be aluminum sheath cable and will have a PVC jacket in corrosive areas. Switchrack control and metering cable will have a lead jacket and overall PVC sheath.

SECTION 49.0

RACEWAY

The plant raceway system will consist of concrete encased underground duct, ladder-type cable tray, and rigid metallic conduit. The raceway system will provide mechanical protection for power and control cable connected to plant equipment.

49.1 UNDERGROUND DUCT SYSTEM

An underground duct system will be provided to route 13.8- and 4.16-kv cables to locations away from the main building complex and where convenient, to loads within the main building. The duct system will consist of 3 in. or larger acrylonitrile-butadiene-styrene (ABS) type EB conduit encased in concrete. Precast concrete manholes will be spaced so that the maximum calculated cable pulling tensions will not be exceeded. All duct lines will be sloped to drain into manholes.

49.2 CABLE TRAY

In the main building complex, wherever possible, cable trays will be used to carry power, control and instrumentation cables. Cable trays will be hot dip galvanized ladder-type with 9 in. rung spacing and will be coated with polyvinyl chloride (PVC) when installed in corrosive areas. Tray covers will be used outdoors and in areas subject to falling objects. Each tray section will be solidly grounded to the plant grounding system.

Tray support design will consider the weight of the tray, cables, and a 200 lb man standing anywhere on any tray 12 in. wide or wider. A load (safety) factor of 2.0 and conservative seismic factors will be utilized. Clearance between the top of a tray and the bottom of the tray above it will be 12 in. Clearance above the top tray will be a minimum of 9 in. At least 24 in. of access will be provided on one side of each cable tray run. Trays will not block access to other equipment.

Separate cable trays will be provided for each of the following cable classes:

1. Medium voltage power (601 to 15,000 volt)
2. Low voltage power (600 volt and below)

3. Control cables
4. Low level signal cables
5. Special systems

For vertical tray stacks the order of elevation from the top will be the same as the above list with the possible exception of the special system trays. In the event that two classes of cables are routed in the same tray, they will be separated by a solid metal partition. All trays will be identified to facilitate tray and cable routing. The sum of the cross-sectional areas of the cables at any point in a tray will not exceed 40 percent of the cross-sectional areas of the cable tray at that point. Power cable trays will be sized to avoid excessive ampere derating of the cables.

Fire stops will be used at all floor, wall, and equipment penetrations. Trays penetrating floors will be completely enclosed for 6 ft above the floor. All vertical paths will be plugged with fire retardant material. Trays will not be used where exposed to physical, fire, or thermal hazard including areas subject to excessive coal dust.

49.3 CONDUIT

Conduit will be used to carry cable from the tray system to equipment for vertical risers exceeding one floor in height, for locations requiring few cables, and in areas environmentally unsuited for cable tray.

Conduit installed outdoors will be galvanized rigid steel. Conduit used in corrosive areas will be PVC coated rigid steel. Aluminum conduit will be used for surface installation within the plant except in corrosive areas. Liquid tight flexible conduit will be used to terminate conduit runs to vibrating machinery. Metallic conduits embedded in concrete will be galvanized rigid steel.

Individual conduit will carry only one cable class, be electrically continuous, and terminate in grounding bushings or into grounded metallic structures.

SECTION 50.0

FREEZE PROTECTION

An electric trace heating freeze protection system will be provided to protect storage tanks and exposed water piping from freezing temperatures. Heat tracing will also be provided for other small piping subject to freezing due to condensation during intermittent or shutdown unit operating conditions.

50.1 HEAT TRACING

The heat tracing will consist of a flat, flexible, low heat-density heating strip. The strip is composed of two parallel copper conductors separated by a continuous core of conducting material. The heat tracing is self-limiting along its entire length in that it controls its watt output in response to actual pipe temperature at every point of application.

50.2 CONTROL

Circuit breakers and alarm cabinets will be located throughout the plant for control, protection, and monitoring of trace heating circuit. Each cabinet will contain 42 single pole, 15 amp, molded case circuit breakers and circuit alarm relays. The continuity of each tracing circuit will be monitored by the circuit alarm relays. In the event of an open tracing circuit, a circuit trouble light will be energized in the cabinet and a common cabinet trouble indication signal will be transmitted to the control room annunciator.

SECTION 51.0

GROUNDING

A plant grounding system will be provided to reduce shock hazard, protect equipment, and allow application of ground relay protection.

The plant grounding system will consist of ground grids made up of soft drawn, stranded, bare copper wire buried beneath the soil. All connections in the grids will be made by the exothermic welding process. The grids will be designed so as to limit step-and-touch potentials to a safe limit during fault conditions.

The grounding system will be made accessible in each room or area containing electrical equipment by means of ground cables running from the buried ground grid up the building structural steel to the various elevations where other grids will be formed beneath the floors.

The plant ground grid will be connected to the switchrack ground grid at a minimum of two places. Remote areas, such as cooling towers, will be connected to the plant ground grid by means of bare copper cable that is run on the top of the underground duct banks that serve these areas.

All electrical equipment, cable trays, conduit, and metallic structures within the plant area will be connected to the grounding system and all fences and rails that extend outside the ground grid area will have insulating sections to prevent transferred potentials.

SECTION 52.0

CORROSION CONTROL

Chemical analyses of soil samples taken for the geotechnical study of the plant site reveal a high concentration of water-soluble salts. Corrosion control will therefore be considered for subsurface metallic structures. Above ground corrosion control is described in Section 58.0

During the detailed engineering phase of the project a soil corrosivity survey will be made to determine which corrosion control methods are required and the extent to which they should be employed.

The accepted methods of corrosion control are the application of properly engineered coatings or cathodic protection, or a combination of the two. Where protective coatings are required they will be applied to the external surfaces of below-grade structures, such as buried pipes and tanks, and to the bottoms of above-grade storage tanks.

Cathodic protection requires the application of continuous supplies of protective current. It also requires that anodes be buried in suitable ground beds, at appropriate distances from the structure, through which a current can be introduced into the soil. Two types of protective current sources can be used. Where considerable current is required it will be obtained from direct current rectifiers connected positively to the anodes and negatively to the protected structure with insulated conductors. Where less protective current will suffice, sacrificial anodes will be used.

SECTION 53.0

BUILDINGS AND STRUCTURES

The buildings and structures will be designed to blend with the surrounding area of the plant site. It is impractical to totally blend this facility with its surroundings, however, through the use of careful and sensitive design, textures, colors, and materials an orderly and visually pleasing Project is possible.

The interaction and balance of rough textured masonry, colors indigenous to the area, landscaping, scale, and the architectural design theme will assure a project which is cognizant of its environment and function.

The basic building materials for the plant enclosures and the walls of miscellaneous buildings will be:

1. Concrete masonry units with integral color.
2. Preformed metal siding with integral color, embossed finish and insulated where required.
3. Metal roof deck, rigid roof insulation over the deck, and built-up roofing.

The integral colors of the concrete masonry units and the metal siding will blend into the overall color scheme of the Project.

Concrete masonry will generally be used on the lower structures and enclosures, affording maximum protection from vehicular damage, while the metal siding will be used for high structures, screens, and miscellaneous buildings on the site. These materials are readily available, suitable for the purpose, flexible, "factory-finished", and need little, if any, maintenance.

All structures, foundations, and structural components of the buildings will be designed in accordance with accepted engineering practices.

53.1 DESCRIPTIONS OF BUILDINGS AND STRUCTURES

53.1.1 TURBINE-GENERATOR BUILDING

The turbine-generator building, as shown in Figures E2 and E3, will be a continuous structure for all four units. The building will be approximately 1200 ft long, 120 ft wide, and 120 ft high. It will be completely enclosed with masonry walls from the ground to the operating deck level and uninsulated metal siding from the operating deck level to the top of the parapet walls. The heating, ventilating, and air-conditioning (HVAC) building appendant on the south side of the turbine-generator building, will also be enclosed with uninsulated metal siding and louvers.

Vertical fenestration will accentuate the fluted motif of the vertical siding. The pull-off points, which support the power connection between the main transformer and the switchracks, will be incorporated into these fenestrated elements.

53.1.2 TURBINE-GENERATOR AND CONDENSER PEDESTAL

The turbine-generator pedestal will be a space frame made of heavily reinforced concrete. Concrete is proposed over steel because of its high dampening effect in absorbing forced vibrations and low conductivity in withstanding high temperatures with little damage, whereas steel is sensitive to high temperatures and has lower dampening qualities. However, an economic study will be made during detailed design comparing steel and concrete turbine-generator pedestals.

The condenser will be located below the turbine generator and will be mounted on the ground foundation along with the space frame of the turbine generator.

Design considerations will include normal loading, seismic loading, and accidental conditions such as electrical short circuits or mechanical failures. Included in the design parameters will be limitations on deflections, loadings, stiffness, differential settlement, concrete shrinkage, and the natural frequency of the structures as compared to that of the turbine generator.

53.1.3 BOILER BUILDING

The boiler building, as shown in Figures E2 and E3, will be substantially enclosed with a roof and uninsulated metal siding from ground level to the top of the boiler.

The size of each boiler building will be approximately 194 x 236 x 284 ft high.

The conveyor gallery will be enclosed with a roof and uninsulated metal siding and will be a dust-tight enclosure.

The elevator shaft and the machine room will be roofed and enclosed with uninsulated metal siding to match the turbine-generator enclosure.

The structural system will be of the braced-frame type construction with all wind and seismic loads transmitted to the foundations by a vertical bracing system. Horizontal bracing or concrete floor diaphragm action will transmit lateral loads to the resisting vertical frames.

53.1.4 STACKS

One 750 ft high stack, located as shown in Figure B1, will be provided for each pair of units. The concrete stacks will have an approximate outside diameter of 70 ft at the top and a somewhat larger diameter at the bottom. Each stack will be constructed of reinforced concrete with two separate steel liners.

The stacks will comply with the requirements of ACI 307, "Specifications for the Design and Construction of Reinforced Concrete Chimneys". The seismic design will be done once dynamically, using the criteria given in Section 53.2.2 and again statically using the requirements of ACI 307 and a use factor (U) of 2.0. Utilization of this use factor will help assure that the stacks will be relatively damage-free and capable of operation after a strong earthquake.

The stack liners will be approximately 30 ft in diameter at the top. The liners will comply (including insulation, internal coatings and clearance) with Appendix 1 of ACI 307.

The stack analysis will include stresses due to the temperature gradient through the concrete. Gas temperatures within the stack liners will range from 170 to 285F. If there is a mechanical equipment failure, the temperature may rise to 400F for up to 1 hr. Outside ambient temperature range from 0 degree F to 100F. Gas velocities in the stack liners will be approximately 70 fps.

Markings on the stack, if required, will be provided in accordance with the requirements of the Federal Aviation Administration (FAA). Stack lighting is described in Section 46.3.

An Underwriter's Laboratories, Inc., approved lightning protection system will be provided for grounding all exposed steel. Stack grounding is described in Section 51.0.

A ladder extending the full height of the stack and circumferential platforms will be provided for stack maintenance and inspection. An elevator will be installed in each stack as described in Section 27.4. A steel cover will be provided at the top of each stack to weatherproof the area between the steel liners and the concrete structure.

The stack will be founded on bedrock with an allowable bearing capacity of 20,000 to 30,000 psf.

53.1.5 CONTROL BAY

There will be one control bay, as shown in Figures B14 and B15, four stories high with a total floor area of 27,200 sq ft located between each pair of units. Each control bay will be completely enclosed with walls of metal studs and cement plaster which are thermally and accoustically insulated.

The following spaces will be provided within the control bay:

1. First floor - switchgear room, battery rooms, 480-volt room.

2. Second floor - relay room, communications room, instrument repair shop, chemical feed room.

3. Third floor - terminal room, men's toilet and locker room.

4. Fourth floor - control room, chemical laboratory, offices, kitchen, men's and women's toilets.

53.1.6 ADMINISTRATION BUILDING

The administration building, as shown in Figures B1 and E4, will be a one-story structure with an approximate floor area of 10,000 sq ft. It will be located east of Unit 4, near the entrance to the plant.

The basic function/areas within the administration building will be as follows:

1. Reception

2. Conference/Training/Briefing

3. Offices
   a. Engineers
   b. Plant support
   c. Plant security
   d. Rail operations
   e. Employment/Personnel

4. Clerical

5. Toilets/Locker Room/Shower/Lunchroom

6. Non-Active Spaces
   a. Storage
   b. Records, Files
   c. Supplies

7. Mechanical Equipment/Electrical & Telephone Vault/Fire Control Equipment, Storage

The building will be arranged about landscaped interior courts as described in Section 56.0. The lobby will control entry to the circulation corridors. All functions will be near to each other, and most spaces will enjoy an exterior view, either to the outside or to the interior landscaped courts.

The building will be concrete block with (local) sandstone rubble facing. Coal masonry accents will state the theme of the plant and provide the second of the "anthropological" colors to be used in this building: red ochre, black, yellow, ochre, and white. Doors, frames, and windows will be hollow metal; roof facias, fluted steel, in the same conformation as the siding on other buildings.

Interior volumes will be defined by vinyl-covered partitions and a hung integrated accoustical ceiling. Office floors will be carpeted and service and heavy traffic areas will have polyester terrazzo flooring. The air conditioning equipment will be integrated with the building design. No roof equipment will be used.

53.1.7 WAREHOUSE AND SHOPS

The warehouse and shops building, as shown in Figures B1, B16 and E5, will be a one-story structure with an approximate floor area of 27,000 sq ft located on the east side of Unit 4. This building will be a masonry and steel frame structure with insulated metal siding and metal roof deck.

The building will house a machine shop, warehouse, offices, fuel laboratory, lunch room, toilets, locker room, and first aid room. A 10-ton overhead crane and a 1-ton jib crane will be provided for the machine shop. The warehouse and shops area will have a clear height of approximately 21 ft. Evaporative cooling, heating, and ventilating will be provided. The personnel facilities will be normal ceiling height and will be fully air-conditioned.

53.1.8 AUTOMOTIVE BUILDING

The automotive building, as shown in Figures B1 and B16, will be a one-story structure with a floor area of 4000 sq ft. An automotive service area, office, paint spray and storage room, and a cleaning area will be included within the building as described in Section 30.0. This building will be a masonry and steel frame structure with metal roof deck similar to the warehouse and shops building.

53.1.9 ENGINE HOUSE

The engine house, located as shown in Figure B1, will be a one-story building with a floor area of 23,000 sq ft.

The building will consist of the general work area for maintenance and repair of railroad locomotives and hopper cars, and for ash haul trucks, forklifts, bulldozers, graders, and other large service equipment. The general work area will have approximately 24 ft of clear height. Three tracks will run through the building for repair of locomotives and cars. A service pit and depressed floor area will be provided and a 35-ton overhead crane will be provided for the primary work area. Adjacent to the general work area will be personnel facilities with approximately 13 ft of clear height. The general work area will be provided with evaporative cooling and heated with radiant panels. The personnel areas will be air conditioned, and the storage areas will be ventilated only.

53.1.10 COAL HANDLING BUILDINGS

53.1.10.1 COAL UNLOADING HOPPER BUILDING

The coal unloading hopper building, located as shown in Figure B1, will house the tandem rotary dumpers and track hoppers. An enclosure within the building will serve for the protection of operating personnel.

The building will be a steel-framed structure with uninsulated metal siding and a metal roof deck. The dimensions of the building will be approximately 60 ft wide, 120 ft long, and 60 ft high.

53.1.10.2 COAL SCALE HOUSE

The coal scale house, located as shown in Figure B1, will house the conveyor drives and pulleys, coal weighing scales, and calibrating equipment.

The building will be a steel-framed structure with uninsulated metal siding and a metal roof deck. The building will have a floor area of 1200 sq ft and will be 30 ft high.

53.1.10.3 COAL CRUSHING AND CONTROL BUILDING

The coal crushing and control building, located as shown in Figure B1, will house and support the yard surge bin, conveyor drives and pulleys, magnetic separators, feeders, coal crushers, and primary sampling equipment. An air-conditioned enclosure within the building will serve as office and laboratory for the coal sampling system.

The building will be a steel-framed structure with uninsulated metal siding and a metal roof deck. Dimensions of the building will be approximately 40 ft square and 100 ft high.

53.1.10.4 COAL TRANSFER BUILDING

The coal transfer building, located as shown in Figure B1, will support the drives of Conveyors 3A and 3B, the tail pulley of Conveyor 5, and the conveyor feed chutes. Adequate ventilation will be provided.

The building will be a steel-framed structure with uninsulated metal siding and a metal roof deck. Dimensions of the building will be approximately 40 ft square and 100 ft high.

53.1.10.5 COAL HANDLING CONTROL BUILDING

The coal handling control building, located as shown in Figure B1, will contain the controls and monitoring instruments for all in-plant coal handling equipment. A small office and toilet will be provided within the building.

The building will be a one-story heated and air-conditioned concrete block structure of 1200 sq ft with a metal roof deck.

53.1.11 WATER TREATMENT BUILDING

The water treatment building, located as shown in Figure B1, will contain equipment for the treatment of industrial and domestic water to be used in various plant systems such as circulating water systems and boiler feed makeup softener system.

The building will be a one-story structure, 60 x 100 ft and 20 ft high, using concrete block, insulated metal siding, metal roof deck, and will contain a small office and toilet. The building will be heated, and the office will be air-conditioned.

53.1.12 SEWAGE TREATMENT BUILDING

The sewage treatment building, located as shown in Figure B1, will contain equipment for the treatment of sewage from the various buildings at the plant and the discharge lines leading to the evaporation ponds.

The building will be a one-story masonry structure with a metal roof deck, 20 ft square and 15 ft high and will be freeze protected.

53.1.13 SWITCHGEAR BUILDING

The precipitator and fan bay switchgear building, as shown in Figure B5, will house the 480-volt power and control center switchgear for start/stop control of various motor loads in the precipitator and fan bay areas.

The building will be a one-story steel-framed structure with insulated metal siding and a metal roof deck. The 30 x 60 ft building will be freeze protected.

53.1.14 SCRUBBER AREA CONTROL BUILDING

The scrubber area control building, as shown in Figures B1 and B10, will contain automatic control equipment for the S02 scrubber systems, consisting of monitoring and recording instruments, alarm annunciators, and a laboratory for the sampling and testing of S02 scrubber water. In addition, the building will house the 4.16-kv switchgear and 480-volt power and control centers for start/stop control of various motor loads in the scrubber and ash handling system.

The building will be a one-story heated and air-conditioned concrete block structure of 1500 sq ft with a metal roof deck. A small office and toilet will be provided.

53.1.15 FREMONT RIVER PUMP HOUSE

The pump house, as shown in Figures A13 and A14 and described in Section 6.0, will be a one-story structure of approximately 2400 sq ft with a clear height of approximately 30 ft.

This building will be a masonry and steel frame structure with an insulated metal siding and a metal roof deck.

There will be a mezzanine deck containing a control room and storage area. A toilet will be provided at ground floor.

53.1.16 RESERVOIR PUMP HOUSE

The water supply pump house, as shown in Figure A18 and described in Section 6.0, will be a one-story structure of approximately 6600 sq ft with a clear height of approximately 20 ft.

This building will be a masonry and steel frame structure with an insulated metal siding and a metal roof deck.

A wing of this structure will contain a control room, storage area, and a toilet.

53.1.17 SWITCHYARD CONTROL BUILDING

The switchyard control building, located as shown in Figure B1, will house switchyard control equipment as described in Section 37.0.

The building will be a one-story concrete block structure with an area of 7500 sq ft. Heating and air-conditioning will be provided for the control room and the relay and microwave room. A storage area and toilet will be provided.

53.1.18 CONVERTER TERMINAL BUILDING

This structure is described in Volume III, Section 4.0.

53.2 STRUCTURAL DESIGN CONSIDERATIONS

All structures, foundations, and structural components of the buildings will be designed in accordance with accepted engineering practices, meeting or exceeding the requirements of the codes listed in Section 60.0.

Structural considerations of the turbine and condenser pedestals and stacks are covered in Section 53.1.2.

Dead loads (all permanent loads such as the weight of the structural members and permanent equipment) will be included in the analysis of each structure. Live loads (all loads which are not permanent or can be moved such as trucks, occupants, and snow) will be accounted for by applying the uniformly distributed loads listed in Table 53-1 over the area under consideration.

TABLE 53-1

MINIMUM UNIFORMLY DISTRIBUTED LIVE LOADS*

	Location	psf
1.	Stairways	100
2.	Building Roof	20
3.	Offices and Assembly Rooms	100
4.	Corridors	100
5.	Rest Rooms and Locker Rooms	100
6.	Warehouse Floor	250
7.	Shop Floor	250
8.	Control Building Floors	125
9.	Laboratories	100
10.	Cable Rooms	150
11.	Battery Rooms	100
12.	Floors, Steel Grating	175
13.	Floors, Concrete	175
14.	Boiler Area Operating Deck	250
15.	Platforms	125
16.	Turbine-Generator Operating Deck	250
17.	Turbine-Generator Pedestal Area	250
18.	Turbine-Generator Mezzanine Deck	150

*Except where special equipment loads control

Required construction loads will also be considered in the structural analysis.

53.2.1 WIND LOADING CRITERIA

Major structures will comply with the 25-psf zone of the "Uniform Building Codes" (UBC) Allowable Resultant Wind Pressures Table. Non-critical facilities will comply with the requirements of the 20-psf zone. However, the two stacks will comply with the wind pressure requirements of ACI 307.

Structures sensitive to vibrations such as conveyor housings, elevator housings, and any flexible structure will be checked for instability due to galloping and flutter.

Pressures acting on the interior surfaces of walls and roofs will comply with the section on internal pressure of the "Timber Construction Manual".

53.2.2 SITE SEISMICITY

The site is located outside the zones of high seismicity. The highly seismic zones of Southern California, western Nevada and Montana are between 400 and 500 miles away. The moderately active seismic region of northern Utah is approximately 250 miles north of the site.

The closest, moderate-sized recorded earthquake occurred over 30 miles southwest of the site. Its magnitude was approximately 4.5 on the Richter scale. The site is located in the UBC's Seismic Zone 2. In the early 1900's two non-instrumental earthquakes of magnitude 6.0 to 6.9 occurred approximately 60 miles northwest of the site.

Reported earthquakes in the area surrounding the site are shown in Figure E1. "Non-instrumental" earthquakes as used on the map and in this report means the data obtained is based primarily on personal reports of an earthquake felt by local inhabitants. In addition, some confirmation using seismograph data may have occurred.

No earthquake epicenters have been recorded within 20 miles of the site, and no faulting due to earthquakes was found at the site.

There is the possibility, although the probability is low, of potentially destructive shaking if an earthquake of moderate magnitude (5.5 to 6.0) is centered near the plant site (approximately 15 miles or closer). This could produce a ground acceleration of approximately 8 seconds duration of strong shaking with a peak acceleration of 12 percent g according to Dr. G. W. Housner (Ref 1). Woodward-Clyde Consultants (Ref 2) suggest a possible peak acceleration of 15 percent g.

Extensive regional faulting is present north and west with some minor faulting to the east and south. The Thousand Lake, Sevier, and Tushar faults are located approximately 50 miles or more to the west and northwest of the site.

The heavier buildings and equipment will be located on bedrock while lighter items will be on bedrock or shallow compacted fill. Therefore, no liquefaction, surface rupturing or serious settlement of the soil is expected due to earthquake forces.

There is also expected to be no "magnification" of seismic forces due to thick layers of soft alluvium. Woodward-Cylde Consultants report that the site consists mainly of exposed bedrock with seismic velocities of 2600 to 16,000 fps.

In summary, the chances of a "large" magnitude earthquake are small. However, a "moderate" earthquake could occur. Therefore, the critical items will be designed for a peak acceleration of 15 percent g (horizontal) with a vertical acceleration of 80 percent of the horizontal. The less critical items will be designed according to the UBC, Zone 2.

53.3 FOUNDATIONS

The soil deposits, usually less than 4 ft deep, are local and tenuous and the bedrock is exposed over most of the site. Woodward-Clyde Consultants (Ref 2) reported that the bedrock has seismic velocities of 2600 to 16,000 fps which indicates dense rock.

The allowable bearing loads will be 20,000 to 30,000 psf for bedrock and 2000 to 4000 psf for compacted fill for the first foot of depth. The allowable load for compacted fill may be increased by 500 to 1000 psf for each additional foot for the next 5 ft (Ref 2).

It is anticipated that excavation and augering for foundations will be difficult. In order to minimize the amount of excavation, spread or mat type footings in conjunction with rock anchors to resist uplift will be used.

Structures, buildings, and equipment will not be located on both cut and compacted fill. Minimum safety factors for overturning and slipping will be 1.5 and 1.1, respectively. Concrete for the footings will be designed to resist corrosion potential of the soil. The allowable bearing loads for footing design and the excavation methods for construction will be determined in later studies during detail design.

53.4 QUANTITIES OF STEEL AND CONCRETE

The approximate quantities of structural steel and concrete for buildings and structures that are described above in this section are 28,000 tons and 180,000 cu yd, respectively. These quantities are exclusive of coal mines, roads, and a new community.

SECTION 54.0

SITE GRADING, DRAINAGE, AND FLOOD PROTECTION

The grading, drainage, and flood protection for the power plant improvements shown in Figure B1 is described in this section, except that specific grading and drainage features for the solid waste disposal and the evaporation pond areas are described in Section 55.0.

54.1 GRADING

Existing drainage patterns at the plant site are in a northerly and northwesterly direction across the site at an average grade of about 1 to 2 percent to the Salt Wash.

The plant site will be graded in a stepped grading pattern, in the direction of natural flow, toward the Salt Wash. All large facilities such as buildings, stacks, and the conveyor system will be constructed totally in cut or fill (but not on both) to eliminate differential settlement. In order to base foundations in firm material, the power block will be founded entirely in cut. Foundation descriptions are covered more fully in Section 53.3. Excess cut material will be used in the construction of evaporation ponds and active coal storage dikes. Wherever possible all building, road, and railroad subgrade filling will be done with local sandstone and siltstone materials.

54.1.1 SITE GEOLOGY AND MATERIALS

The site can be divided roughly into two geologic areas. The northern one-half of the site is generally underlain by Carmel formation bedrock composed of over 100 ft of gypsum with occasional layers of sandstone and siltstone. The southern one-half of the site is generally underlain by the Entrada formation which, in this area, consists of a well-consolidated, sometimes cemented siltstone with a significant fine sand content, approaching a sandstone.

The Carmel gypsum and interbedded sandstone and siltstone are well-bedded with strata varying from fractions of an inch to several feet in thickness. The bedding appears to be roughly horizontal although locally erratic because of the intense folding. Extreme distress is shown in all Carmel exposures in canyon and wash walls. Near the center of the site, the Carmel dips under the Entrada demonstrating a site bedding inclination gently south. Except where exposed in erosional features, the contact of the Entrada and the Carmel rocks is masked by a thin veneer of surface, wind-blown sand and silt deposits. This veneer may be from inches to a few feet thick.

More detailed descriptions of site geology and soil properties are found in Woodward-Clyde Consultants Report, "Phase II Geotechnical Study, Salt Wash Plant Site, Caineville Dam Site" (Ref 2).

54.1.2 METHODS OF GRADING AND FOUNDATION EXCAVATION

Small diameter drilling, up to 12 in. in diameter, can be expected to proceed with rapid penetration in the drill holes. Larger diameter drillings with crane augers,, flight augers or bucket augers are expected to encounter considerable difficulties.

Ripping of the Entrada formation by bulldozers (Caterpiller D-9 or equivalent) with double rippers will probably be effective, although difficult. Excavation for trenches and spread footings in rock with a seismic velocity of 7500 fps or greater will probably require blasting.

The Carmel formation will be a difficult formation to excavate. Some blasting in the thick gypsum beds may be required. Where the beds are thin and siltstone interbeds are present, a D-9 bulldozer may be able to excavate the rock by heavy ripping.

54.1.3 DESIGN SLOPES

Permanent construction slopes can be filled on 1-1/2:1 (1-1/2 horizontal to 1 vertical) in both the Entrada and Carmel formations. In cut the Entrada should not exceed 1-1/2:1 in weathered formations, however, most vertical cuts may be made in fresh bedrock. Permanent cut slopes in Carmel formation may be made at 1:1. Temporary construction slopes in general may be cut at 1/2:1.

54.1.4 GRADING QUANTITIES

Site grading will involve the cutting of approximately 1,240,000 cu yd of materials and the filling of approximately 750,000 cu yd of materials. Excess materials will be used to construct pads for all temporary construction facilities such as trailer pads, warehouse pads, construction storage areas, parking areas, and for temporary site drainage channels and holding dikes. Approximately 2,200,000 cu yd of additional cut and fill will be required to grade the evaporation ponds. In final design, grades will be adjusted to achieve a balance of cut and fill volumes for all grading to the sites.

54.1.5 UNIQUE PROBLEMS

In the Carmel formation there is potential for expansive soil problems. Anhydrite if saturated, becomes gypsum with an expansion factor of 30 to 50 percent. In areas of foundations or roads and walkways, a fairly thick base of aggregate and sand will be used to minimize expansive soil problems associated with the gypsum. Without the thick base material, pavement heaves; sidewalks, gutters, curbs, and yard improvements of portland cement concrete could crack and deflect erratically.

54.2 DRAINAGE AND FLOOD PROTECTION

54.2.1 PRECIPITATION

The two closest weather stations to the site are at Capitol Reef National Park (Fruita) and Hanksville. The National Oceanographic and Atmospheric Administration (NOAA) Weather Station No. 42-1171-07 at Capitol Reef National Park Headquarters shows a 30-yr (1941-1970) mean annual precipitation of 7.24 in. with a high year of 13.78 in. and low year of 3.91 in. During the 4-month period from July through October, 53 percent of the annual precipitation falls, mostly from scattered convective storms which are common to this part of the country during late summer and early fall.

A plot of isopluvials by the U. S. Department of Commerce over the plant site reveals the expectancy of precipitation and duration as shown in Table 54-1.

TABLE 54-1

PRECIPITATION EXPECTANCY

Probability of Return (yr)	24 hr Duration (in)	6 hr Duration (in)
5	1.3	1.0
10	1.6	1.2
50	2.2	1.6
100	2.4	1.8

54.2.2 DESIGN CRITERIA

The primary concern at the plant site will be flood protection, safe operation, and access consistent with the value of the improvements and the reliability expected from the station.

Major and vital improvements will be afforded protection from events of up to a 50-yr return period. This will be applicable to improvements such as major storm drains and culverts for access roads around the power block. For lesser improvements, where short duration flooding will result in limited damage, a 10-yr return period event will be the design criteria.

54.2.3 MAJOR FLOODS

There are no flood hazards associated with the plant site. The general drainage patterns on the site are shown in Figure A6. The Salt Wash is the only stream near the site. It flows easterly along the northerly boundary of the site and drains an area of about 350 sq mi. A 100-yr storm would cause a stream depth of less than 20 ft adjacent to the site. The 100-yr storm was estimated using a 6-hr duration rainfall and Synder's synthetic hydrograph method as having a peak flow of 22,000 cfs. The rainfall intensity and occurrence was based on the U.S. Department of Commerce Environmental Science Service Administration, Isopluvial Map, dated June 1968. All plant improvements are outside and above these flood limits. The plant improvements are all more than 20 ft above the flood limits and are in excess of 400 ft from these limits.

54.2.4 LOCAL DRAINAGE AND FLOOD PROTECTION

Within the developed facility and building areas, natural drainage courses will be directed around improvements in either open gunited channels or culverts and returned to the natural drainage course as shown in Figure A6. Culverts will direct flow under walkways, roads, and railroads. Drainage will be conveyed in a closed conduit storm drain through the heavily developed power block area and returned to the natural drainage course.

Areas in which runoff may possibly bear oil or other contaminants will be served by separate area drains as described in Section 35.0. This runoff will be treated as industrial wastewater and will not be allowed to drain to a natural channel.

A preliminary grading plan and the drainage pattern are shown in Figure A6.

SECTION 55.0

WASTE MANAGEMENT SYSTEMS

Wastes from the plant will be isolated, collected, and disposed of in accordance with applicable state and federal regulations. The waste will also be managed consistent with plant operations and protection of the surrounding environment. This section describes the management of wastes which have been categorized into solid and liquid wastes.

55.1 SOLID WASTE SYSTEM

Solid waste from the plant includes ash and scrubber sludge, water treatment sludge, construction refuse, and plant operations refuse.

55.1.1 ASH AND SCRUBBER SLUDGE

55.1.1.1 GENERAL DESCRIPTION

The two types of ash from a coal-fired power plant are bottom ash and fly ash.

Bottom ash drops to the bottom of the boilers after combustion and is collected there in a water-filled hopper. It consists of relatively few fines, is gray to black in color, quite angular, and has porous surface texture. It will be dewatered by decantation while in a holding hopper, where it is held for 24 hrs before being discharged for disposal.

Fly ash is the fine, lightweight particulate material that rises out of the boilers and economizers in the flue gases, and is collected by the electrostatic precipitators and flue gas desulfurization system. It is dry and dusty, and water must be added at the plant (15 to 20 percent by weight) to control the dust during transportation from the plant and to facilitate compaction at the disposal site.

Scrubber sludge is the waste product of flue gas desulfurization (SO_2 scrubber). It has the consistancy of thick paint and remains in a thixotropic state for long periods of time. When placed in a fill by itself, it is a structurally unstable material requiring either chemical stabilization or containment inside dikes. Scrubber sludge will be thickened to 50 to 60 percent solids in the plant by thickeners.

55.1.1.2 POTENTIAL USES AND DISPOSAL METHODS CONSIDERED FOR ASH AND SCRUBBER SLUDGE

Ash and scrubber sludge are marketable by-products. Ash can be used in structural landfill, as aggregates, as a concrete admixture, for road stabilization, and in the manufacture of building bricks. Scrubber sludge can be processed and used in structural landfills. These uses of the waste products require markets for the products economically close to the plant site. Such markets do not exist at the present time.

Until markets do develop, the waste products can be stockpiled. This requires stockpiling the bottom ash, fly ash, and scrubber sludge in separate areas at a disposal site or at separate sites. Each material exhibits specific characteristics as described previously and requires specialized equipment and/or disposal methods.

Ash and scrubber sludge can be combined and disposed of permanently in a landfill operation. When they are to be disposed of together, fly ash is mixed with scrubber sludge at the plant in a pugmill. The mixing will increase the strength properties of the landfill and eliminate the need to dewater the scrubber sludge beyond the above-mentioned 60 percent. The bottom ash can be incorporated in the same fill as the sludge-fly ash mix. This method requires only one disposal site with all products going to one location in the disposal site. It minimizes the equipment required at the disposal site and minimizes dust control problems by being able to transport a damp mixture to the disposal site instead of the dry fly ash. Also, less surface area of disposed material is exposed and less water is used in handling the mix than with separate disposal.

55.1.1.3 DISPOSAL METHOD CHOSEN

There is no assurance that markets will develop for any of the waste products; therefore, ash and scrubber sludge will be mixed and disposed of permanently in a controlled landfill operation. This procedure is the least expensive alternate and the least complicated. If economic markets do develop for any of these plant waste products, the products will be diverted and the disposal plan will be adjusted accordingly.

55.1.1.4 TRANSPORTATION OF THE WASTE

A system of haul roads, as shown in Figure A7, and trucks will be utilized for the transportation of ash and sludge. The ash haul roads will be 36 ft in paved width and will conform to the respective typical section shown in Figure A23. The trucks will haul the waste from holding silos at the plant and unload at the disposal site. The trucks will be water-tight end dump trucks to prevent leakage along the roadway. The size of the trucks will range from 40 ton to 100 ton as determined by final design. The number of trucks utilized at any time will be sufficient to provide a reserve for equipment breakdowns and for planned maintenance with operation of the plant at full capacity.

55.1.1.5 LOCATION OF THE DISPOSAL SITE

Two alternative disposal sites have been selected, with one site being preferred over the other. The alternative sites and haul routes are shown in Figure A7. They range in distance from the plant from approximately 2 miles to approximately 5 miles. These alternative sites were selected on the basis of engineering, geotechnical, and environmental constraints. The proposed site is favored because the haul distance is the shortest. However, it is founded on Entrada Sandstone which may require an impervious lining if it is found that the recompaction of the Entrada Sandstone is not sufficient to provide an impervious membrane. The alternative site is founded on the impermeable Mancos Shale formation which will not require lining. Both sites are in canyons to minimize visibility from surrounding areas.

55.1.1.6 SIZE OF SITE REQUIRED AND RATE OF DISPOSAL

It is estimated that approximately 53 million tons of ash and scrubber sludge will be produced during the operational life of the plant. The total volume produced will be approximately 63 million cu yd. For landfill with an average depth of 75 ft, approximately 520 acres will be required for the fill at the disposal site. Additional area will be required to accommodate drainage facilities, haul roads, and an evaporation pond.

It will be necessary to dispose of an average of 4100 tons per day during the plant life. The annual plant loading schedule and ash content of coal burned will vary during plant life; therefore, the actual daily rate of disposal will also fluctuate. Disposal facilities will be designed for a maximum peak rate of 9600 tons per day, which represents 100 percent plant capacity and coal at 12 percent ash content.

55.1.1.7 ENVIRONMENTAL PROTECTION MEASURES

Dust control during transportation of fly ash will be handled by moisture conditioning and mixing with scrubber sludge at the plant. Dust control measures at the disposal site will include additional moisture conditioning as necessary by water truck. When the fill reaches design grade, a layer of native soils will be placed over the surface to control any potential dust from the solid wastes.

Since land area tributary to the disposal site is minimal, the surface runoff from this tributary will be retained and evaporated with runoff from the fill. The top of the fill will be stepped and diked so that precipitation that falls on that specific area will pond on the fill where it will evaporate. Runoff from the side slopes of the fill and the tributary area to the ash disposal area will be routed to an evaporation pond at the mouth of the canyon. This pond will be sized for a 100-yr storm. It will be lined with an impermeable lining to prevent seepage into groundwater aquifers.

Any potential leachates from the fill will be intercepted by a drainage blanket and a network of drainage pipes at the bottom of the fill. Any liquid intercepted will be routed to an observation and monitoring sump and then to the above-mentioned evaporation pond.

Protection against contamination of groundwaters will be further assured by the fact that the native materials under the site are formations of extremely low permeability.

The native foundation material, at the alternative site is impervious either in place, or with minimal scarification and recompaction. At the proposed site, the foundation material is predominently Entrada Sandstone and it may be necessary to construct an impervious base using locally available Mancos Shale (recompacted permeability is approximately 0.00000001 cmps).

55.1.1.8 DISPOSAL PROCEDURES TO BE FOLLOWED

In order to minimize dust and runoff water problems, only that small portion of the disposal area necessary for the unloading, spreading, and/or drying of the waste material will be worked at one time. A phased development of the entire fill will be planned.

A 2-ft minimum thickness layer of native material will be removed and stockpiled for each phase. The subsurface drainage blanket with a system of drain pipes draining to the sump and evaporation pond will be constructed prior to commencing fill operation. Bottom ash will be processed and incorporated in the drainage blanket.

The fly ash and scrubber sludge mix will either be mixed with the bottom ash at the disposal site prior to compaction or placed and compacted in separate lifts or zones. The trucks will unload at the disposal site and the waste will be spread for compaction by tractors or motorgraders. Moisture conditioning will be adjusted at the plant for optimization of low water consumption, stability of compacted fill, ease of handling, and low compaction effort. A water truck will be available for any additional moisture conditioning required at the disposal site. Compaction equipment will be utilized as necessary to assure proper density of the fill.

A test fill will be constructed soon after start-up to determine the density required for stability and impermeability of the fill. Periodic testing of the fill will be done to guarantee the specified density is met.

A controlled earth fill embankment will be constructed at the toe of the fill for stability. This measure will be unnecessary if further investigation proves the sludge-ash mixture to be sufficiently stable as placed.

During placement of the fill, surface runoff will be controlled by constructing a down canyon dike, and sloping the fill back toward the throat of the canyon where it will pond and evaporate. After a phase reaches final grade, a 2-ft layer of stockpiled native soil will be placed on the surface and compacted. Final surface contours of the fill will be blended with adjacent topography. The area will either be seeded, or other engineering measures will be implemented to prevent erosion. Tests will be conducted on various revegetation plans to determine the feasibility of this approach. If revegetation is impractical, the area will be either treated with chemical/mechanical soil stabilizers or terraced and drainage structures provided to intercept drainage. "Zero Erosion" is probably impossible to attain so the evaporation pond will also serve as a sediment catch basin.

55.1.2 WATER TREATMENT SLUDGE

Water treatment sludge generated from the domestic water clarifier and the lime makeup water softeners will be disposed of in the solid waste disposal area either by, first mixing at the plant with the fly ash and scrubber sludge in the pugmills or by hauling directly to the disposal area and mixing with the fill in place.

55.1.3 CONSTRUCTION REFUSE

During plant construction, refuse will be collected and disposed of in the ash disposal area. A minimum cover of 6 in. of soil will be maintained over the refuse to minimize scattering due to wind or sanitary problems. Soil for cover will be borrowed from within the disposal area.

55.1.4 PLANT OPERATION REFUSE

Plant operation refuse will be disposed of in the ash disposal area. The refuse transported to the ash disposal area will include all solid and semisolid wastes from maintenance and operation of the plant, including shop and offices. A minimum cover of 6 in. of soil will be maintained over the refuse to minimize scattering due to wind or sanitary problems. Soil for cover will be borrowed from within the disposal area.

55.2 LIQUID WASTE SYSTEM

Liquid wastes from the plant include plant wastewater, storm runoff, and sanitary waste.

All liquid waste will be managed in accordance with applicable state and federal regulations. To meet the provisions of the

Federal Water Pollution Control Act of 1972, the waste systems will provide for "zero pollutant discharge" to either surface or groundwater bodies.

55.2.1 PLANT WASTEWATER

The plant wastewater results from four main functions in the operation of the plant. The sources and quantities are listed as follows:

Sources	Average Quantity (gpm)
1. Cooling tower blowdown	300
2. Demineralizer and make-up softeners	160
3. Various maintenance wash waters	200
4. Storm runoff	15
Total	675

A more detailed breakdown of the origins and quantities of plant wastewater are shown in the Plant Water Balance, Figure B41. The total plant wastewater volume will average approximately 1100 acre-ft/yr.

To meet the criterion of "zero discharge" to surface or groundwater bodies, the water must either be evaporated or reclaimed. Reclamation has been determined to be more expensive than solar evaporation at the proposed plant site; therefore, all plant wastewater will be disposed of via evaporation ponds.

The evaporation ponds will be sized to contain all settleable and dissolved solids during the life of the plant (approximately 2.4 ft) plus storage of the total plant wastewater for 2 yrs (approximately 6 ft), plus freeboard (2 ft). The 2-yr storage will be sufficient to provide for prolonged occurrences of low evaporation rate, high precipitation, and increased flows during plant start-up operations. The total surface area required is based on an average annual evaporation rate of 44 in. per yr, and an average annual precipitation rate of 8 in. per yr for the area. These rates indicate an average net evaporation rate of 36 in. per yr which may be reduced slightly by the effects of salinity.

The evaporation ponds will be located in the northwest area of the plant site as shown in Figure A5. The total net evaporation pond area will be approximately 400 acres.

The total evaporation pond area will be sectionalized and made up of individual ponds. The individual pond surface area will average about 50 acres each with a maximum reach of 3000 ft to minimize wave action. The ponds will be terraced into the existing topography to minimize grading. Dikes will separate the ponds and contain the water. Gate works and waterways will be provided to facilitate transfer by gravity or isolation of water volumes.

The bottom of the ponds will be lined with 1 ft of native clay-like soils (permeability of 0.01 ft per yr). A 6-in. layer of sand will be placed on the clay to protect it from drying and cracking. The sides of the ponds will be lined with impervious asphalt. These measures will protect all ground or surface water bodies from seepage.

Settleable solids, dissolved salts, and chemicals contained in the wastewater will ultimately settle or precipitate to the bottom of the ponds. When all water has been evaporated from a pond, a dry lake will have been formed with a salt cake residue on the floor. This residue will be left uncovered at the end of the plant's operational life. The height of the dikes surrounding the ponds, approximately 8 ft above the volume of residue, will be sufficient to contain the residue.

55.2.2 STORM RUNOFF

To ensure against pollutants being transported from the site by storm runoff, the following management plan will be implemented.

Area drains for the entire power block including the turbine generators, boilers, precipitators, air preheaters, stacks, and scrubbers as well as the shops and water treatment areas will be provided as part of the industrial wastewater system as described in Section 35.0. Runoff from these areas will be collected, cleaned of any oil, and routed to the evaporation ponds and treated as plant wastewater.

Additionally, runoff from the ash handling, scrubber thickners, and coal unloading, storage, and conveyor areas will be isolated and conveyed to evaporation ponds.

The fuel oil storage tank area will be diked to contain all oil in the event of tank rupture and fire. The enclosed area will be sufficiently large to contain and evaporate storm runoff.

The switchyard area will include oil-filled electrical equipment. This area will be enclosed by a dike, and a gravel fill will be provided with sufficient volume to contain oil which may result from equipment rupture plus the maximum rainfall volume expected in a 24-hr period during a 10-yr frequency storm.

Construction equipment and material storage areas, if containing potential pollutant materials, will be diked during the construction activity such that all storm runoff will be contained and evaporated.

The remainder of the plant site will be graded as described in Section 54.0 and the runoff will ultimately return to its natural drainage course.

55.2.3 SANITARY WASTE SYSTEM

The Sanitary Waste System will include a pipeline collection network discharging to a sewage treatment plant and effluent discharge lines leading to the evaporation ponds. The entire system will handle a peak daily capacity of 40 gpd per person. For the total operating force of approximately 550 personnel, it is estimated that 410 will be on duty each day for all three work shifts, and that the total daily sewage capacity required will be 16,400 gpd.

The pipeline collection network will utilize gravity flow where possible, and serve all structures having sanitary facilities.

Preliminary design studies indicate that a sewage lagoon treatment is best suited for conditions at the site. The lagoon will be three-celled to handle the above daily load, and the lagoon size necessary will be about 3 to 5 acres. Under the criterion of zero pollutant discharge, the lagoon will be suitably lined to allow no percolation to underlying soil formations. Just prior to entering the lagoon, the waste will be ground by a comminutor unit. Express effluent, not evaporated in the lagoon system, will be chlorinated and discharged into the evaporation ponds.

There may be a problem with odor during a period of less than a month each year during ice breakup. This will depend upon wind direction and force. If necessary, an activated sludge unit will be added to the system between the comminutor unit and the lagoon. Because of the anticipated low temperatures in winter, near 0 degree F, the activated sludge unit, if required, will be housed in a building of about 20 ft by 30 ft.

Maintenance will require a twice weekly inspection of the treatment plant. The pump motors will be telemetered from the main control room to warn of pump breakdown.

The entire system will be built in accordance with the Code of Water Disposal Regulation, Utah State Board of Health (S.D.H - San-99-I-65, revised).

SECTION 56.0

LANDSCAPING

The landscaping will retain, rather than replace, as much as possible of the existing elements of the desert; while a transition from the natural environment to the buildings will be provided by a minimum of introduced plants. The plant landscaping will attempt to provide an attractive setting for the plant. Some 2,000,000 sq ft (46 acres) will be planted. Three degrees of landscaping will be provided, as shown in Figure E6.

56.1 DESIGN CRITERIA

The following design criteria will be followed in order to complete the aesthetic union of plant and site:

1. Restoration of all unoccupied areas to a natural and functioning condition, after construction is completed.

2. Creation of an aesthetic environment through use of indigenous plant and mineral materials.

3. Mitigation of intruding elements, and replenishing of only those areas which have been permanently altered by operation of the plant through introduced species.

4. Control of the elements for comfort, safety, or permanence (such as windbreaks or erosion control) through native plants in general and limited use of introduced species.

5. Irrigation, where necessary, will be minimal.

56.2 DESCRIPTIVE ANALYSIS

Of the landscaping proposed, the largest part will be 1,200,000 sq ft of "minimal" planting. This will be largely limited to ground covers in the general area subject to moisture fallout from cooling towers. The Baccharis to be used here has been selected as resistant to the salts and minerals which could be expected in cooling tower fallout, as well as extremes of heat and cold. Additionally, "minimal" landscaping will be employed as a base for the two denser degrees of planting and the use of this ground cover on coal-retaining berms will control erosion.

"Intermediate" landscaping will consist largely of native shrubs and smaller native trees which will respond to, or at least not actively resist, some cultivation and maintenance. The total area of this type of planting will be 700,000 sq ft. The purpose and function of this degree of landscaping will be to restore the natural vegetation of the area in a somewhat denser form, which will act as "foundation planting" for the whole site, and will restore the habitat function to the vicinity's ecology which will have been preempted by buildings or equipment. The greatest part will flank the main entrance road and provide some visual relief when the eye first encounters the bulk of the plant.

"Intensive" landscaping, 100,000 sq ft in area, will have beautification as its primary function. Consisting mostly of specimen trees, other specimen plants, and some boulder work, this type will exist chiefly in the immediate vicinity of staffed buildings. At the switchyard it will provide screening of the usual ground level clutter of switchyards. Along the entrance road, trees will delineate the driveway and screen the coal storage piles. The administration building will be the location of special treatment. As the visitor center and the nerve center of the Project, it will have parking lot screening and windbreaking. The entrance will be accented by a composition of native stone, coal, and other minerals, with smaller native plants which would otherwise not count in the larger landscape. The atriums of the building will be heavily planted for the shade and delight of the building occupants.

Only the "intensive" plantings will receive an automatic electronically operated sprinkler system. "Intermediate" and "minimal" density plantings will have minimal irrigation consisting of hose bibs or bubblers as required. Ground covers will be watered by temporary systems with snap-on rainbird type heads, until they are established and can survive without further attention.

Whole soil amendments may be necessary in the early stages of establishing plants. There will be no mass importation of topsoil. Plants will be adapted to the existing soil rather than replacing soil.

56.3 PLANT LIST

A partial list of plants which will be considered for use in the landscaping of the power plant site is as follows:

Botanical Name	Common Name
Populus Fremonti	Fremont Cottonwood
Populus Tremuloides	Quaking Aspen
Populus Wislizeni	Wislizenus Cottonwood
Pinus Ponderosa	Ponderosa Pine
Pinus Flexilis	Limber Pine
Pinus Edulis	Piñon Pine
Pinus Monophylla	Single Leaf Piñon
Pseudotsuga Taxifolia	Douglas Fir
Cupressus Arizonica	Arizona Cypress
Thujopsis Dolobrata	Deerhorn Cedar
Tamarix Hispida	Salt Cedar
Aesculus Hippocastanum	Horse Chestnut
Picea Glauca	Blue Spruce
Picea Pungens	Colorado Spruce
Picea Emgelmanni	Englemann Spruce
Platanus Wright	Arizona Sycamore
Acer Rubrum	Red Maple
Acer Saccharinum	Silver Maple
Acer Saccharinum "Wieri"	Split Leaf Silver Maple
Juniperus Monospermus	Oneseed Juniper
Larrea Tridentata	Sagebrush
Atriplex Canescens	4-Wing Saltbush
Chrysothemis Nauseosus	Chamisa
Baccharis Pilularis	Coyote Bush
Uva Ursi	Beargrape
Quercus Gambeli	Scrub Oak
Nolina Microcarpa	Beargrass
Ephedra	Mormom Tea
Yucca Elata	Soap Weed Yucca
Yucca Baccata Var. Torreyi	Spanish Boyonet
Yucca Glauca	Blue Yucca
Opuntia Eugelmannii	Euglemann's Prickley Pear
Opuntia Rosei	Rose's Pink Flowered Prickley Pear
Opuntia Erinacea, Var. Ursina	Grizzly Bear Opuntia
Fallugia Paradoxa	Apache Plume

SECTION 57.0

PLANT SECURITY

The plant security system will control the access of personnel and visitors to the plant and will isolate the plant's facilities from access by grazing range cattle.

The system will consist of natural barriers, perimeter fencing, motor and manually operated gates, and a security guard station. The plant site includes a significant natural barrier in the form of the bluffs which rise up to Wood Bench on the southern perimeter. An 8-ft high chain link fence will extend from the bluffs to encircle all of the Project facilities on the plant site except for the solid waste disposal site as shown in Figure A5. The solid waste disposal site will not require enclosure by fencing except for its evaporation pond which will be enclosed by a separate fence.

Access through the perimeter fencing will be by remote and manually operated gates. The coal delivery railroad and the solid waste haul road will have motor-operated gates. The operation of the gates will be controlled by tuned-frequency receivers which will open and close the gates upon signal from a portable transmitter on coal train or waste hauling trucks. The plant access road will have a motor-operated gate which will be controlled from the adjacent security guard station which will have communications with the plant security office in the administration building. Manually operated gates will be provided at locations where patrol roads lead to off-site facilities such as the well fields for underground water.

SECTION 58.0

PROTECTIVE COATING AND PAINTING

The principal objective of protective coating systems or of paint systems will be to protect surfaces from harmful environments or to make them aesthetically attractive. Also, these systems will perform other functions such as providing identification, abrasion resistance, light diffusion, cleanliness, and imperviousness. To assure that any or all of these functions are successfully achieved, careful consideration will be given to cost effectiveness, materials' characteristics such as surface preparation requirements, drying or curing, ease of touch-up or repair, and durability.

58.1 MATERIALS

Water based materials will be used extensively, particularly as finish coats. Recent developments and improvements in these materials will afford the following advantages over the traditional oil paints:

1. Rapid drying time permitting short closure time of painting areas.
2. Minimal overspray problems from fall-out contamination.
3. Ease of application, touch-up, and repair.
4. Elimination of costly solvents and thinners.
5. Elimination of fire and explosive hazards.

Types of coatings, paints, and colors will be limited to as small a number as practicable resulting in the following benefits:

1. Simplify work scheduling
2. Minimize storage and inventory requirements

58.2 METAL SURFACES

Steel surfaces subject only to atmospheric exposure will have the surfaces prepared and painted as follows:

1. Surfaces will be abrasive cleaned to the degree described as No. 6 Commercial Blast Cleaning by the Steel Structures Painting Council Surface Preparation Specifications.

2. The paint system will be a two coat system comprised of a corrosion-inhibitive pigmented, universal type, fast drying alkyd primer, and a top coat of a low sheen, scrylic enamel emulsion.

Steel surfaces subject to temperatures above 250F will have surface preparation and protection as follows:

1. Surfaces will be abrasive cleaned to the degree described as No. 10 Near-White Blast Cleaning by the Steel Structures Painting Council Surface Preparation Specifications.

2. The paint system will be a single coat of a modified ethyl silicate inorganic zinc. The material is available in a range of colors, and should serve to satisfy aesthetic as well as corrosion control requirements.

Insulated steel surfaces subject to temperatures above 250F will be cleaned and primed as described above for steel surfaces subject only to atmospheric exposure, but will not receive top coats.

Steel surfaces subject to particularly corrosive environments (chemical exposure, high humidity, splash, and immersion) will receive special heavy-duty coatings over appropriately prepared surfaces and with special primers as required. Coating materials such as epoxies, modified epoxies, and catalyzed polyurethanes will find the widest application in these problem areas.

Non-ferrous metals (aluminum, copper, brass, and other corrosion resistant alloys) will not be painted unless color is specified for identification or for aesthetic purposes. Acrylic enamels will be used for this purpose.

Metal surfaces requiring painting and situated such that maintenance painting will be difficult (girts and subgirts in exposed areas, or equipment placed in areas of very limited space) will receive costlier protection for "permanent" paint service life.

58.3 CONCRETE, MASONRY, AND PLASTER SURFACES

Concrete, masonry, or plaster surfaces to be painted for aesthetic purposes will be given two coat systems of flat or semi-gloss acrylic emulsion paints, the choice being governed by architectural needs. The surface preparation will be as required by the surface condition for the proper adhesion of the paint, and by the texture and finish required for aesthetics.

Surfaces requiring sealing only will receive either a clear waterproofing coating of silicone based on a non-oxidizing gum based material, or a two coat system of clear acrylic emulsion, the choice being determined by architectural considerations.

Surfaces exposed to severly detrimental environments will be protected with heavy-duty coatings similar to systems which will be employed for steel under like conditions.

58.4 COLORS

With the exception of color use conforming to OSHA requirements, architectural criteria will largely govern the selection and distribution of colors.

SECTION 59.0

CONSTRUCTION FACILITIES

The temporary facilities for construction of the generating station and water supply systems will be located at the plant and dam sites and are described in this section. Temporary construction facilities necessary for the coal mine development and coal transportation and transmission line systems construction are not included in this section, but are discussed in Volumes III and IV of this report.

59.1 PLANT SITE

The field engineering office complex; contractors' trailers; medical facilities; warehouses; shops; storage facilities; concrete batch plant; aggregate storage area; concrete and materials testing laboratory; and open storage, working, and parking areas will be located in the plant site area where the majority of the personnel (approximately 2500) will be working. The locations of these temporary facilities are shown in Figure A24.

59.1.1 FIELD ENGINEERING OFFICES

There will be six to eight large, well-insulated trailers totaling approximately 7000 sq ft for use as field engineering offices. These will be located in the field engineering office complex adjacent to and south of the power block as shown in Figure A24. These trailers will provide work space for approximately 60 people.

59.1.2 CONTRACTORS' OFFICES

Trailers for contractors' offices and work space will also be located in the field engineering office complex. Space will be allotted and utilities provided for each contractor. Approximately 10,000 sq ft of additional trailer space for 90 employees is estimated to be the total requirement.

59.1.3 CONCRETE BATCH PLANT

A concrete batch plant will be located on the plant site westerly of the switchyard area as shown in Figure A24. In the immediate proximity of the batch plant will be sand and aggregate storage areas and unloading and conveying facilities.

The batch plant will provide concrete for construction at the plant site, the water supply systems, and other Project facilities where transportation is practical and economical. The location at the plant site is more suitable for the batch plant than other construction locations because the generating station will require more concrete than any other Project facility and because of the availability of construction water and electrical power.

During intense concrete usage, between 130 and 200 cu yd per day will be used, with occasional daily usage of up to 800 cu yd.

59.1.4 CONCRETE AND MATERIALS LABORATORY

For quality control, a concrete and materials testing laboratory will be located in the vicinity of the batch plant. The building will be approximately 1200 sq ft and will be of prefabricated corrugated metal erected on a concrete slab.

59.1.5 WAREHOUSES AND SHOPS

Warehouses, shops, and associated open storage yards and auxiliary buildings will be provided. The following construction shops, warehouses, and auxiliary buildings are contemplated for the site:

1. Pipe and hanger shop
2. Rebar shelter
3. Carpenter shop
4. Materials and parts warehouses
5. Acetylene storage
6. Cement storage
7. Coating shop
8. Paint and storage shop
9. Electric shop
10. Utility building
11. Tool room

12. Change rooms
13. Construction equipment repair shop and yard

It is estimated they will occupy 38,000 sq ft of construction space and will be located in the area shown for warehouses and shops in Figure A24. These temporary facilities will be in addition to the permanent shops and warehouses provided for operation and maintenance of the plant. Most of the buildings for these temporary facilities will be prefabricated corrugated metal structures on concrete slabs, however, trailers may be used where practical.

59.1.6 OPEN STORAGE AND WORKING AREAS

It is estimated that approximately 10 to 20 acres will be required for open storage and working areas. These areas will be limited to the locations shown in Figure A24 as the "Contractors' Storage Areas".

59.1.7 UTILITIES

59.1.7.1 SANITARY FACILITIES

During construction the sanitary sewer system will use both a standard flush toilet system and portable toilets using chemicals or low water usage.

The office and engineering complex will be served by a flush toilet system and will be sized for 200 people or 8000 gpd. Pipelines will be constructed at the beginning of site work to connect with the sewage lagoon in the evaporation pond area. These lines will be sized and later used for the permanent sewage disposal system. A lagoon type treatment facility as described in Section 55.2.3 will be provided. This facility will also be incorporated in the permanent sewage treatment system for the plant.

The remainder of the work force of approximately 2300 men will be serviced by 77 portable toilets. Using chemical or low water volumes, these will be emptied by a pumper tank truck and discharged to the sewage treatment system.

59.1.7.2 WATER

Potable water may have to be trucked to the site initially. As the on-site well field is developed, the water may be of the quality necessary for human consumption. If not, the water will be utilized for other construction water uses and water from the Fremont River will be conveyed to and treated at the site by construction of a temporary pipeline and related facilities. The maximum potable water demand during construction will be approximately 53,000 gpd. The maximum construction water demand for all other usage at the plant site is estimated at 66,000 gpd.

59.1.7.3 ELECTRICAL POWER

Construction electrical service will be provided by Garkane Power Association, Inc., Richfield, Utah. The maximum requirement for construction will be 5 Mw.

Garkane Power Association's present system in the Caineville area is constructed for 69 kv from their Parker Mountain Substation located near Koosharem, Utah to the Caineville area, but energized at 12 kv. The line is supplied from UPL's Sigurd Substation and by a 46/12.5-kv substation at Lyman, Utah 38 miles away.

Garkane Power plans on supplying 69 kv in the Caineville area in 1977 by a 69/138-kv transmission tie line from the Boulder Substation. This line will increase the capacity to an amount sufficient to supply normal loads and 5 Mw for IPP construction power.

Since there is considerable opposition from the National Park Service to the proposed Boulder to Caineville tie line, Garkane Power is studying a second option: Construction of a new 69-kv transmission line from Sigurd to Parker Mountain and converting the remaining portion from Parker Mountain to Caineville to 69 kv. The Caineville area will then be supplied 69 kv from Sigurd.

Since one of the above options is required by Garkane Power regardless of IPP, the environmental assessment will be made and all necessary permits will be acquired independent of this Project.

From the Caineville area, power will be delivered to the plant site via one of the proposed 69-kv transmission lines adjacent to the main access road and as shown in Figure A28.

In the event that neither proposal by Garkane Power will be available for construction power for the Project, one of IPP's proposed 345-kv a-c lines between IPP and UPL's Emery Plant will be constructed early and energized at 69 kv during construction. This alternative will result in a 6 to 12-month delay in the Project while this line is constructed.

59.1.7.4 COMMUNICATIONS

The telephone company responsible for providing telephone service to the plant site region is the Emery County Farmers Union Association. Presently, this company does not have communication ties with the Caineville region. At the start of construction, the Emery County Farmers Union Association will construct new services to the Caineville area sufficient to meet the need of the Project and the new community described in Section 4.0 of Volume IV. The new communication lines will be constructed in the same general corridor as either IPP's proposed coal transportation system, described in Section 2.0 of Volume IV, or IPP's proposed 345-kv a-c transmission lines between IPP and UPL's Emery Plant, described in Section 7.0 of Volume III.

Additional communications will be required between the diversion works, dam site, borrow site, and ash disposal site with the main plant site. This system will be an internal communication system with the communication lines supported on the same pole lines as the electrical service to these areas.

The microwave communication system described in Section 4.0 of Volume III, will also provide direct communication between the plant site and any other system directly tied with DWP's existing microwave system.

59.1.8 MEDICAL FACILITIES

Emergency medical aid service will be required at the plant site at all times during construction. This aid will most likely consist of a person holding a valid first aid certificate, medical supplies in the amount and type approved by a consulting physician, a medical bed, and an area for the treatment of minor physical problems. An ambulance or helicopter service will be provided to move an injured person to the nearest medical treatment center.

Currently, the closest physician and hospital is situated in Richfield, Utah approximately 100 miles from the plant site. It is anticipated that in conjunction with the development of a community to house the construction and permanent workers, new medical facilities will be provided as described in Volume IV. These facilities will then be used in conjunction with the emergency medical aid services provided at the plant site.

59.2 DAM SITE

Located at the dam site will be a single field engineering office trailer (1000 sq ft), a soil laboratory (1600 sq ft), and areas reserved for the contractors' offices and their service facilities. This soil laboratory will serve construction of the Red Desert Dam, the plant site, and the Fremont River diversion works. Approximately 16 engineering, surveying, and inspection personnel and 100 contractor's personnel will be employed at the dam site. Three portable toilets will be furnished at the office site and will be serviced by a truck from the plant site. Drinking water will be trucked to the work locations in portable iced coolers. Construction water will either be trucked or piped in temporary pipelines from either wells in the area or the Fremont River. Telephone and electrical power will be provided by early completion of a portion of the permanent electrical transmission pole line between the plant and dam sites.

59.3 CONSTRUCTION MATERIAL BORROW

Rock and earth materials for construction and operation will be developed from borrow sites on and close to the plant site providing it is more economical than hauling from distant commercial sources. The location and suitability of materials in potential borrow sites is based upon a reconnaissance level study performed by Woodward-Clyde Consultants (Ref 1). Rock construction material will be needed as aggregate for concrete and asphalt mixes, for road subbase, and for protection of the impervious lining of the evaporation ponds. Earth construction and operation material will be needed for the impervious lining of the evaporation ponds and for use at the ash disposal areas. The proposed borrow sites are shown in Figure A29.

It is estimated that approximately 200,000 cu yd of sand and gravel will be needed for concrete aggregate for the proposed plant, pumping plants, diversion works, and other dam facilities. Approximately 100,000 cu yd of sand and gravel will be needed for aggregate for asphaltic concrete used to pave new access roads associated with the plant and the sides of the evaporation ponds and an additional 230,000 cu yd of crushed aggregate will be needed for the road subbase. In addition, approximately 320,000 cu yd of sand will be needed for the evaporation pond bottoms. Total aggregate needs for the plant, therefore, will be approximately 850,000 cu yd.

The nearest source of rock to the plant site suitable for concrete aggregate is the volcanic rock on the talus slopes of Black Mountain, designated Site A in Figure A29 and located in Sections 12 and 13, T 27 S, R 7 E, SLM and Section 18, T 27 S, R 8 E, SLM. This material will require crushing to obtain the required aggregate gradation and, therefore, is also the preferred location for the source of crushed aggregate base and aggregate for asphaltic concrete. Sand and pea size gravel can also be obtained adjacent to Black Mountain from the area designated Site B in Figure A29. Another source of sand and pea size gravel is the area designated Site C, but due to it being further away, Site B is the preferred site. Site B is located in Sections 13, 22, 23, 24, and 25, T 27 S, R 7 E, SLM. Borrow sites B and C are moderately well-cemented gravelly sand deposits which caps several mesas in the area. These are probably pediment gravels whose beds are up to 15 ft to 20 ft thick. Sites A, B, and C each has millions of cu yd of material suitable for borrow.

Preliminary estimates show that approximately 340,000 cu yd of processed material will be obtained from Site A and approximately 510,000 cu yd of processed material will be obtained from Site B. It is estimated that the average borrow depth at Site A and B will be 20 ft and 10 ft, respectively. With estimated wasteage, bulks, etc., approximately 13 acres of borrow area will be required at Site A and approximately 53 acres at Site B.

A temporary rock crushing and screening plant will be located in Section 18, T 27 S, R 8 E, SLM, near the base of Black Mountain in the vicinity of the rock material borrow sites. An unpaved access road approximately 9 miles in length will be constructed from the plant site, westerly in Salt Wash around Black Mountain and join the existing unpaved road in the Middle Desert. This road will later serve as an access road to various well locations. In addition, a temporary unpaved access road, approximately 3 miles in length, will be developed leading to the borrow areas and rockcrushing plant. These roads will be approximately 36 ft wide. The location of the temporary rockcrushing and screening plant and the access roads are shown in Figure A29. Approximately six employees will work at the rockcrushing and screening plant and at the borrow sites. A portable toilet will be located in this area and serviced by a truck from the plant site. Drinking and construction water will be provided by truck from the plant site. Temporary electrical power will either be supplied from the plant site over a portion of the permanent overhead pole lines which will serve well fields in this direction from the plant site, or from portable motor generators.

Mobile loading equipment will load aggregate on gravel haul trucks. Truck route from the aggregate location to the generating plant site will be 13 miles. It is possible other sources of aggregate might be required for special structural concrete at the plant site. This aggregate would be delivered to the site as regular truck haul.

An aggregate storage pile will be developed at the construction site to provide a supply when hauling is halted due to inclement weather and to meet peak construction demands.

No 9/1/80 Bck

An aggregate processing plant will be constructed at the plant site to support the batch mixing plant. The temporary aggregate processing plant will consist of a hopper, classifier, heavy-media separator, and associated conveyors for transfer and storage. The classified product will be stored adjacent to the batch plant at the construction site. Up to 1200 gpm of water will be supplied by the construction water pipeline for washing of the aggregates. Wastewater discharge will be discharged to one of the permanent evaporation ponds which will be constructed in advance.

Approximately 650,000 cu yd of clayey impervious material will be required for lining the bottoms of the evaporation ponds. This material can be obtained from the Mancos Shale formation which is located in the following three areas: 1) just east of the plant site, 2) east of the North Caineville Mesa, and 3) southeast of the dam site. The first area, which is designated Site D in Figure A29 and is located in Section 16 and 17, T 27 S, R 9 E, SLM, is the closest source and is therefore the preferred borrow site. Borrow is not expected to exceed 15 ft in depth and should require approximately 32 acres of borrow area for the evaporation ponds. At the present time, it is estimated that the native material underlying the solid waste disposal site will be suitable as an impervious base. If after further tests, this is found not to be the case, it will be necessary to place impervious material from Site D to form the impervious base. The maximum amount of material that would be required will be approximately 1,000,000 cu yd.

During the operation of the plant, approximately 1,320,000 cu yd of native material will be required for fill that will be placed and compacted on top of the solid waste disposal area. Much of this material will be generated from the bottom of the disposal area that is excavated and stockpiled prior to the placement of the solid waste. The remainder of the material will be obtained from adjacent areas designated Site E in Figure A29.

As construction work is completed, all temporary structures, fencing, utilities, and refuse will be removed. The cleared areas will be blended into the normal landscape of the vicinity. Borrow sites will be smoothed and graded to blend with the adjacent landscape. All temporary construction access roads, developed but not designed as permanent patrol or access roads, will be closed and similarly rehabilitated. Where applicable, cleared or graded areas will be stabilized and seeded to restore to the original condition.

Additional borrow requirements associated with IPP and their location are discussed in other portions of this report as follows: the Red Desert Dam or the Fremont Dam are described in Section 6.0; the transmission lines in Volume III; and the coal haul railroad and community development in Volume IV.

SECTION 60.0

DESIGN STANDARDS

The design of the Project will be in accordance with the latest editions of the standards, codes and specifications listed in this section.

60.1 MECHANICAL

1. American National Standard Code for Pressure Piping, Power Piping, ANSI B31.1.

60.2 ELECTRICAL

1. American National Standards Institute Standard for Rotating Electrical Machinery, ANSI C50.
2. Institute of Electrical and Electronic Engineers Standard for Isolated-Phase Bus, IEEE 298.
3. Institute of Electrical and Electronic Engineers Standard for Switchgear Assemblies including Metal-Enclosed Bus, IEEE 27.
4. American National Standards Institute Standard for Regulators and Reactors ANSI C57.
5. National Electrical Manufacturers Association Standards for Transformers, Regulators and Reactors, NEMA TR-1.
6. National Electrical Manufacturers Association Standard for Motors and Generators, NEMA MG-1 and MG-2.
7. American National Standards Institute Standards for Power Switchgear, ANSI C37.
8. Institute of Electrical and Electronic Engineers Standard for Wire and Cable, IEEE 383.
9. American National Standard Institute National Electrical Safety Code, ANSI C2.
10. The National Electrical Code.

60.3 CIVIL AND STRUCTURAL

1. International Conference of Building Officials, Uniform Building Code.

2. American Concrete Institute, Building Code Requirements for Reinforced Concrete.

3. American Institute of Steel Construction, Manuals of Steel Construction.

4. Concrete Reinforcing Steel Institute, CRSI Design Handbook.

5. Occupational Safety and Health Administration Standards, Part II, Department of Labor Publication.

6. American Welding Society, Standard Code for Welding in Building Construction and Standard Specifications for Welded Highway and Railway Bridges.

7. Utah Highway Department Standard Specifications for Road and Bridge Construction.

8. Federal Aviation Administration, Department of Transportation, Requirements for Navigational Lighting on Very High Structures.

9. American Institute of Timber Construction, Timber Construction Manual.

10. American Association of State Highway Officials, Standard Specifications for Highway Bridges.

11. Standard Specifications for Public Works Construction, Written and Promulgated by Southern California Chapter American Public Works Association and Southern California District Associated General Contractors of California joint Cooperative Committee.

SECTION 61.0

PERMITS

A list of types of permits required for construction and operation of the power plant, water reservoir and well fields is shown in Table 61-1.

TABLE 61-1

PERMITS

Facility or Function	Type of Permit Required	Agency
Power Plant		
Acquisition of site	Land acquisition Zoning Permit to proceed	BLM & State County Commission BLM & State
Excavation of site	Grading	County Engineer
Structures	Building	County Engineer
Dikes or dams water storage	Dam	State Engineer
Wastewater from plant	National pollutant discharge elimination	State Division of Health
Domestic water supply		State Division of Health
Stack emission control	Air pollution	Utah Air Conservation Committee
Stack and cooling tower	Air navigation clearances	Federal Aviation Authority
Sanitary sewage	Waste discharge	State Division of Health

Facility or Function	Type of Permit Required	Agency
Water Supply		
Diversion works	Dam	State Engineer
	Water rights	State Division of Water Rights
	Land use	BLM & County
	Dredged or fill material	U.S. Corps of Engineers
Pumping plants	Land use	BLM & County
	Building	County Engineer
Water supply conduits	Land use	BLM & State
	Water course crossings	County Engineer
	Encroachments	Existing utilities, i.e., water, gas, oil, R.R., power, telephone, etc.
Storage reservoir	Dam	State Engineer
	Water rights	State Division of Water Rights
	Land use	BLM & State
Wells	Water rights	State Division of Water Rights
	Land use	BLM & State
Wells and dewatering facilities	Use of tracers in groundwater studies	State Division of Health
Access		
Roads	Land use	BLM & State
Ingress and egress to existing roads	Driveway	State Division of Highways & County
Transporting heavy equipment	Oversize loads	State Division of Highways & County
Pipelines	Land use	BLM, State & County
	Encroachment	BLM, State & County

Facility or Function	Type of Permit Required	Agency
Solid Waste Disposal		
	Land use	BLM, State & County
	Grading-land fill	State Division of Health & County
	Dam	State Engineer
Temporary Construction Facilities		
Roads	Land use	BLM, State & County
Borrow pits, quarries, etc.	Land use	BLM, State & County
Housing, community	Land use	BLM, State & County
	Sewer	State Division of Health
	Water supply	State Division of Health
Meteorological station	Special land use permit	BLM
Wastewater	National pollution discharge elimination system	State Division of Health & County
Sewers	Waste disposal	State Division of Health & County
Domestic water supply	Water supply	State Division of Health & County

SECTION 62.0

PLANT DESIGN AND CONSTRUCTION SCHEDULE

The IPP plant design and construction schedule for Unit 1 is shown in Figure B49. Schedules for Units 2, 3, and 4 will be similar. This schedule identifies the main plant design and construction activities and defines the work items to be performed in each activity.

Activities related to transmission system and coal supply system are not included in this schedule. The transmission design and construction schedule is included and discussed in Volume III and the coal supply schedule is discussed in Volume IV. The IPP Project Schedule, included in Volume I, addresses the overall aspects of the Project.

Time periods are in reference to the date of commercial operation of Unit 1 and are not related to actual dates. This method was chosen to keep the design and construction schedule current in spite of occasional adjustments that may have to be made to the IPP Project Schedule.

The design and construction schedule indicates that it will require 59 months from the actual start of construction until the commercial operation date of Unit 1. The critical path on this schedule with regard to on-site construction is as follows:

Line No.	Work Activity	Time Period	Months Required
2	Access & Site Grading	59 to 50	9
3	Construction Facilities at Plant Site	50 to 47	3
8	Excavation of Boiler Area	47 to 44	3
9	Foundations in Boiler Area	44 to 39	5
10	Steel Erection in Boiler Area	39 to 33-1/2	5-1/2
24	Boiler Erection	33-1/2 to 7-1/2	26
--	Start-up Operations	7-1/2 to 0	7-1/2
--	Commercial Operation	0	0
		Total Months Required	59

This schedule will serve as a future basis for more detailed design and construction schedules which will need to be developed as the Project progresses. These detailed schedules will be prepared when detailed interrelationships of activities and end objectives have been better defined.

SECTION 63.0

ABBREVIATIONS

acre-feet	acre-ft
acrylonitrile-butadiene-styrene	ABS
actual cubic feet per minute	acfm
all weather ground	AWG
alternating current (noun)	ac
alternating current (adjective)	a-c
American Concrete Institute	ACI
American Institute of Steel Construction	AISC
American Institute Timber Construction	AITC
American Society for Testing and Materials	ASTM
American Society of Mechanical Engineers	ASME
American Welding Society	AWS
American Wire Gauge	AWG
ampere, amperes	amp
automatic turbine start-up	ATS
basic impulse/insulation level	bil
boiler-turbine control	BTC
boiler-turbine-generator	BTG
brake horsepower	BHP
British thermal unit	Btu
Bureau of Land Management	BLM
Calcium Oxide	CaO
California Environmental Quality Act	CEQA
cathode-ray tube	CRT
centimeters per second	cmps
Concrete Reinforcing Steel Institute	CRSI
cross-linked polyethylene	XLP
cubic centimeters	cc
cubic centimeters per liter	cc/l
cubic feet	cu ft
cubic feet per minute	cfm
cubic feet per second	cfs
cubic inch	cu in.
cubic yards	cu yd
current-to-pneumatic	I/P
decibel A scale - The sound level as measured by the standard A-scale sound level meter. The standard A-scale sound level meter measures the sound pressure level referenced to a sound pressure of 0.0002 microbars and also compensates for the lower sensitivity of the human ear to low frequency sounds by de-emphasizing the low frequency portion of the noise spectrum.	dBA
degree Centigrade	C

degree Fahrenheit (Exception: 0 degree F)	F
Denver and Rio Grande Western Railroad	D&RG
Department of Water and Power, City of Los Angeles	DWP
direct-current (noun)	dc
direct current (adjective)	d-c
East	E
electro-hydraulic control	EHC
emergency load center	ELC
emergency load control center	ELCC
Energy Minerals Allocation Recommendation System	EMARS
Environmental Impact Report	EIR
Environmental Impact Statement	EIS
estimate	est
ethylene propylene rubber	EPR
Federal Aviation Administration	FAA
feet	ft
feet per minute	fpm
feet per second	fps
forced air cooled	FA
forced-oil-air cooled	FOA
gallon, gallons	gal
gallons per day	gpd
gallons per hour	gph
gallons per minute	gpm
gravity	g
grounded-wye	gnd Y
heating, ventilating, and air conditioning	HVAC
hertz	Hz
horsepower	hp
hour, hours	hr,hrs
Illuminating Engineering Society	IES
inch	in.
Institute of Electrical and Electronic Engineers	IEEE
Intermountain Consumers Power Association	ICPA
Intermountain Power Project	IPP
International Conference of Building Officials	ICBO
Interstate Highway 70	I-70
kilocircular mils	kcmil
kilovolt	kv
kilowatt	kw
killowatt-hour	kwh
less than	LT
liter	l
manual-automatic	M/A
megavolt-ampere	Mva
megavolt-ampere-reactive	Mvar
megawatt	Mw
mercury	Hg
mercury, absolute	HgA
miles per hour	mph

milligrams per liter	mg/l
million tons per year	mty
National Electrical Code	NEC
National Electrical Manufacturers Association	NEMA
National Environmental Policy Act	NEPA
National Fire Protection Association	NFPA
National Oceanographic and Atmospheric Administration	NOAA
net positive suction head	NPSH
nitrogen oxide	NOx
number, numbers	No.,Nos.
Occupational Safety and Health Administration	OSHA
ohm-centimeter	ohm-cm
oil-air	OA
operating (operation) and maintenance	O&M
outside diameter	OD
parts per million	ppm
pounds per square inch, absolute	psia
polyethylene	PE
polyvinyl chloride	PVC
pound, pounds	lb
pounds per cubic foot	pcf
pounds per square foot	psf
pounds per square inch	psi
pounds per square inch, gage	psig
power circuit breaker	PCB
private automatic branch exchange	PABX
Range	R
Reference	Ref
revolutions per minute	rpm
root mean square	rms
Salt Lake Meridian	SLM
South	S
Southern California Edison Company	SCE
square foot	sq ft
square inch	sq in.
square miles	sq mi
standard cubic foot	scf
standard cubic feet per minute	scfm
subsynchronous resonance	SRR
sulfur dioxide	SO2
thousand pounds per square foot	Ksf
tons per hour	TPH
total dissolved solids	TDS
total dyanmic head	TDH
Township	T
Uniform Building Code	UBC
uninterruptable power supply	UPS
Utah Division of State Lands	UDSL
Utah Power and Light Company	UPL
Utah State Highway 24	U-24

versus	vs.
Wayne County Water Conservancy District	WCWCD
Westinghouse Environmental Systems Department	WESD
year, years	yr, yrs

SECTION 64.0

LIST OF REFERENCES

All references listed in this Section are on file in the Project Engineer's office at the following address:

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Project Engineer
Intermountain Power Project
Room 933B, General Office Building
Department of Water and Power
Post Office Box 111
Los Angeles, California 90051

Telephone Number (213) 481-5352

References that are marked as confidential are restricted for use by the IPP participants and governmental agencies only.

1.0 LOCATION

1. DWP, "IPP Site Selection and Evaluation Report", October 1974.

2. WESD, "Power Plant Site Recommendation for IPP", October 1974.

3.0 LAND

1. DWP, "IPP Site Acquisition Study", April 9, 1975.

6.0 WATER SUPPLY

1. State of Utah Division of Water Resources, "Fremont River Study", 1975.

2. DWP, "IPP Surface Water Investigation Report", November 1976.

3. Woodward-Clyde Consultants, "Phase II Geotechnical Study, Salt Wash Plant Site, Caineville Dam Site for IPP", June 24, 1975.

4. DWP, "IPP Groundwater Investigation Report", July 1976.

9.0 DRAFT SYSTEM

1. DWP, "Induced and Forced Draft Fan Drive Study for IPP", April 1975.

10.0 MAIN BOILER EMISSION CONTROL SYSTEM

1. A. V. Slack, "Status of Advanced FGD Process", Special Report, April 14, 1975 (Confidential).

2. A. V. Slack, "Technology for Power Plant Emission Control, Quarterly Status Report", September 29, 1975 (Confidentital).

3. United States Environmental Protection Agency, "Proceedings: Symposium on Flue Gas Desulfurization", Volumes I and II, Atlanta, Georgia, November 1975.

4. Coal and the Environment Technical Conference, "Coal Utilization Symposium - Focus on SO2 Emission Control", Louisville, Kentucky, October 1974.

5. M. W. Kellogg, Proposal to DWP, August 1975.

6. A. V. Slack, "IPP, Selection and Design of SO2 Scrubbers", August 1975.

7. KVB Engineering, Inc., "Oxides of Nitrogen Control System Study for IPP", Special Report, February 1975 (Confidential).

11.0 LIME SUPPLY AND HANDLING SYSTEM

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1. DWP, "Turbine Throttle Condition Study for IPP", December 1975.

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1. DWP, "Number of Feedwater Heaters Study for IPP", November 1974.
2. DWP, "Single vs. Dual Feedwater Heater String Economic Comparison for IPP", April 1975.
3. DWP, "Main Steam Condenser Study for IPP", August 1975.
4. DWP, "Boiler Feed and Booster Pump Location Study for IPP", January 1975.

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1. DWP, "Evaporator vs. Demineralizer Study for IPP", March 1975.

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1. George W. Housner, "Recommended Seismic Design Criteria for IPP", May 29, 1975.
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54.0 SITE GRADING, DRAINAGE, AND FLOOD PROTECTION

1. Woodward-Clyde Consultants, "Phase II Geotechnical Study, Salt Wash Plant Site, Cainville Dam Site for IPP", June 24, 1975.

59.0 CONSTRUCTION FACILITIES

1. Woodward-Clyde Consultants, "Phase II Geotechnical Study, Salt Wash Plant Site, Caineville Dam Site for IPP", June 24, 1975.

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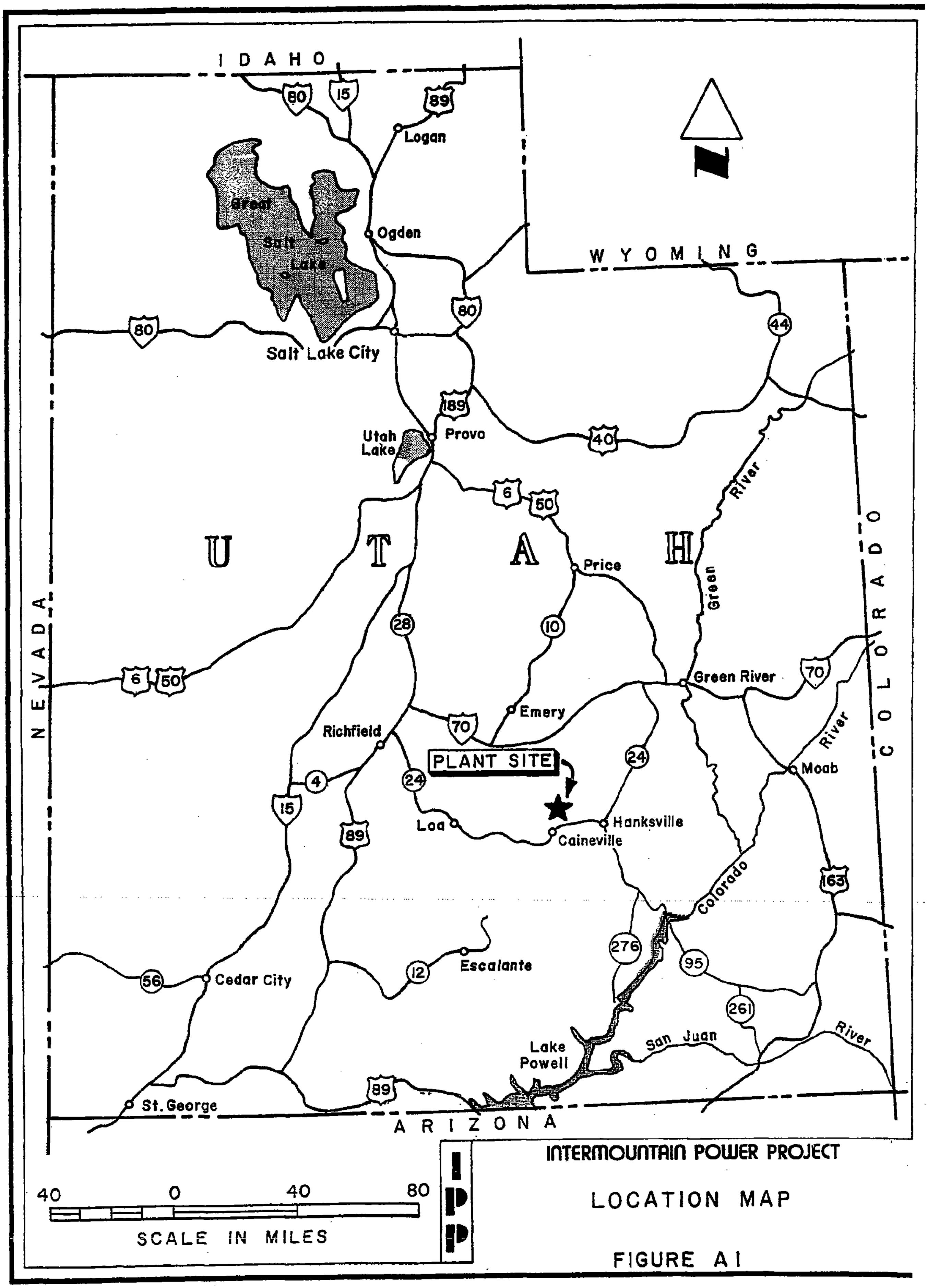
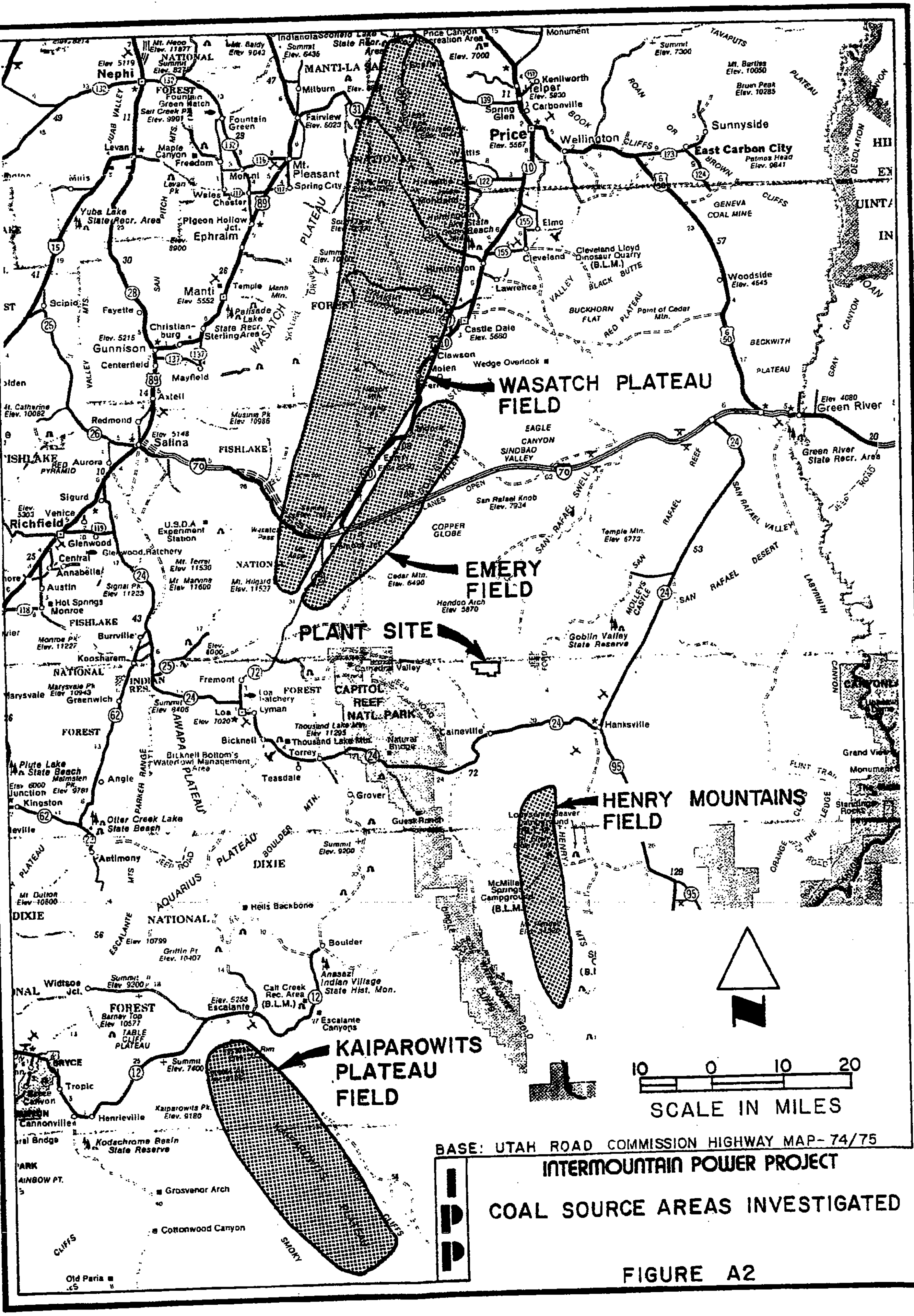


INTERMOUNTAIN POWER PROJECT

LOCATION MAP

FIGURE A1

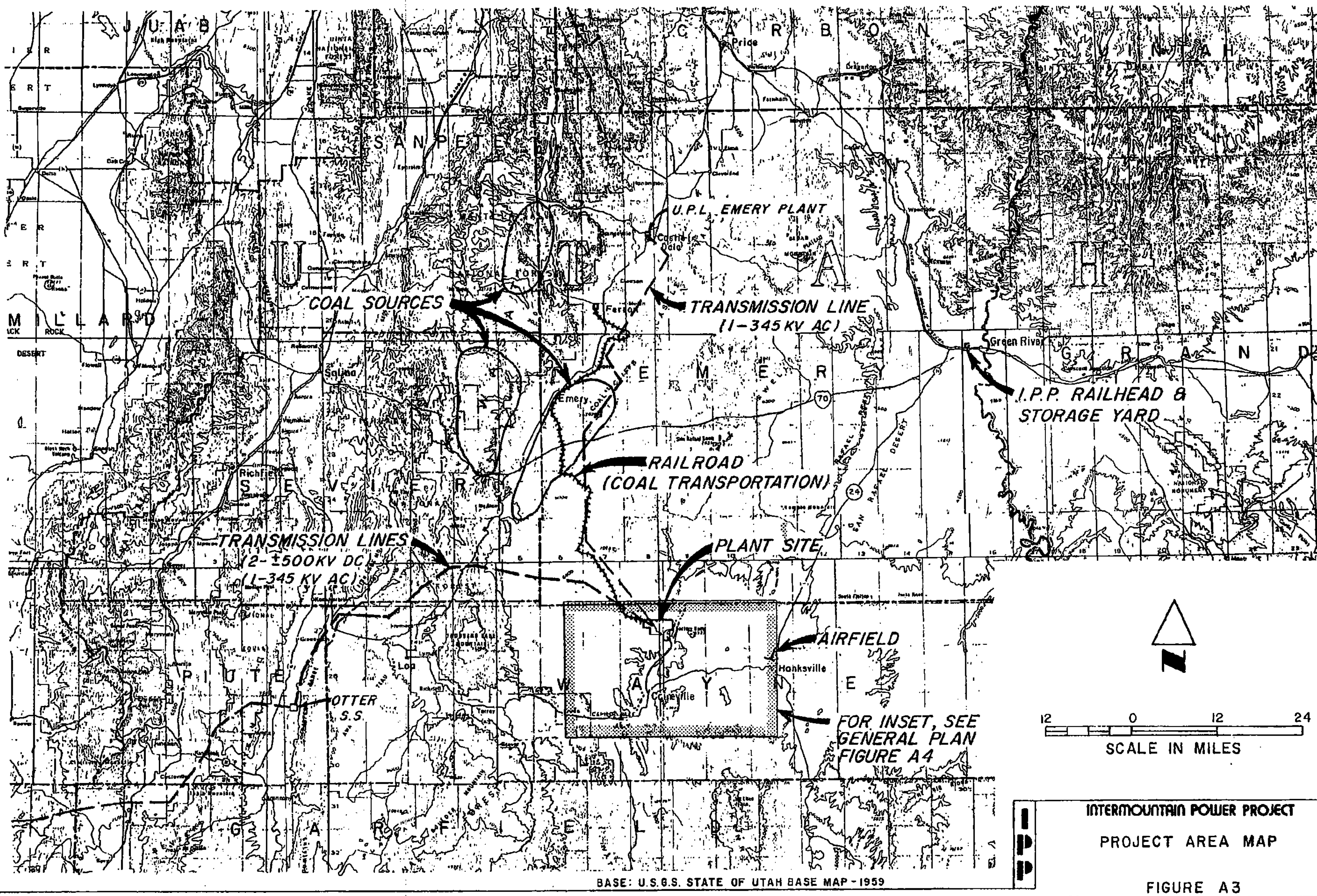


IPP

INTERMOUNTAIN POWER PROJECT

COAL SOURCE AREAS INVESTIGATED

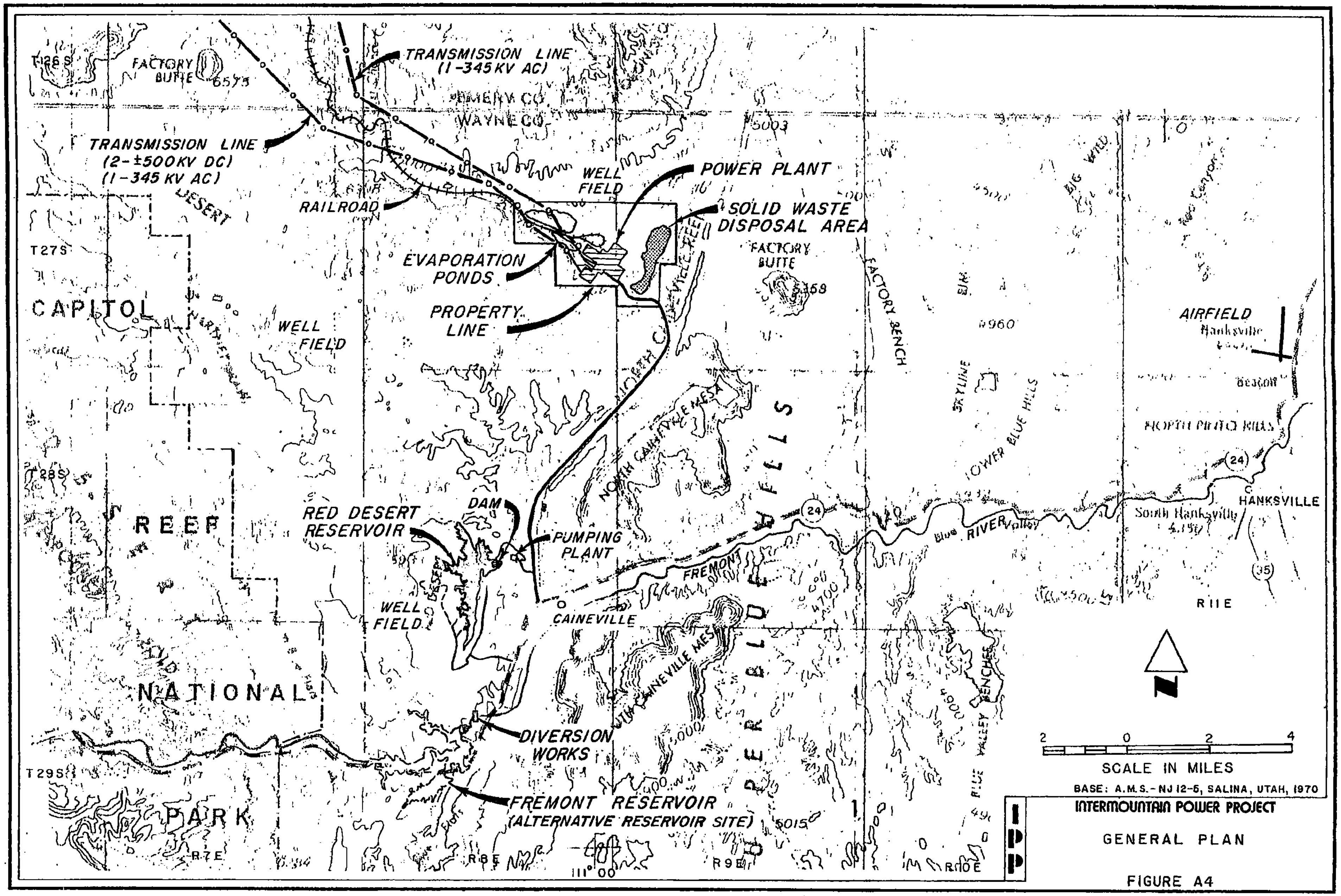
FIGURE A2



INTERMOUNTAIN POWER PROJECT

PROJECT AREA MAP

FIGURE A3

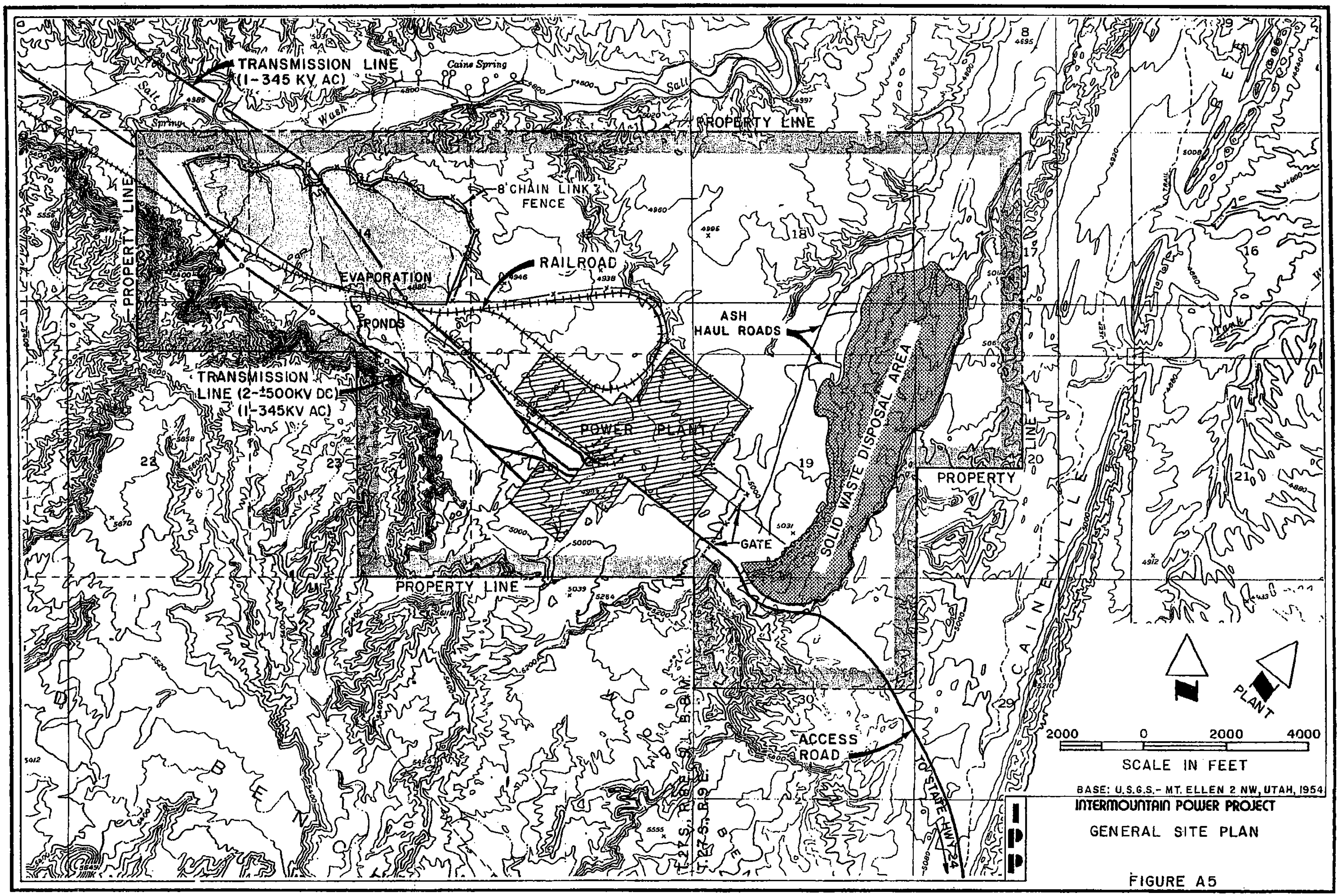


BASE: A.M.S.-NJ 12-5, SALINA, UTAH, 1970

INTERMOUNTAIN POWER PROJECT

GENERAL PLAN

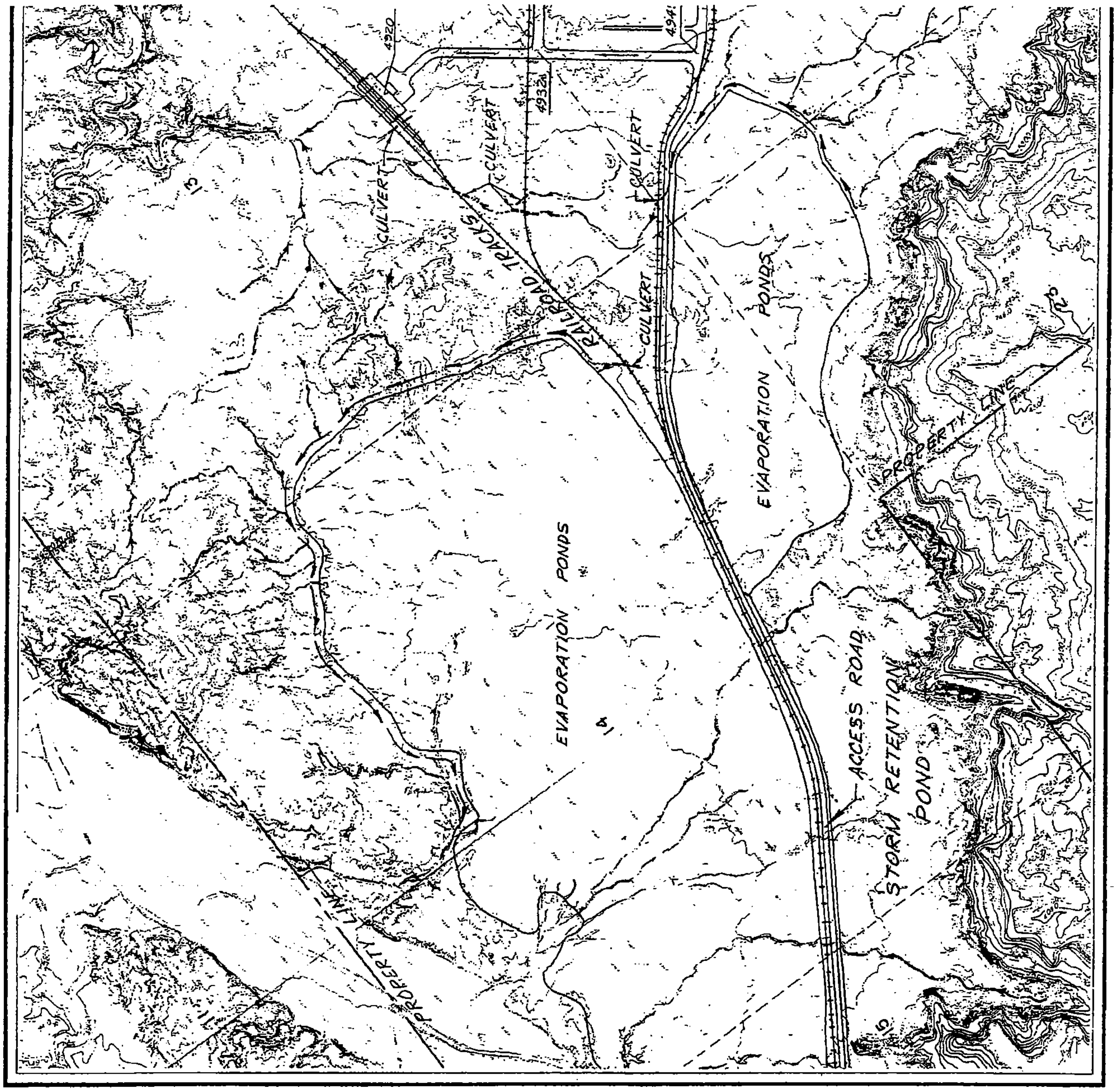
FIGURE A4

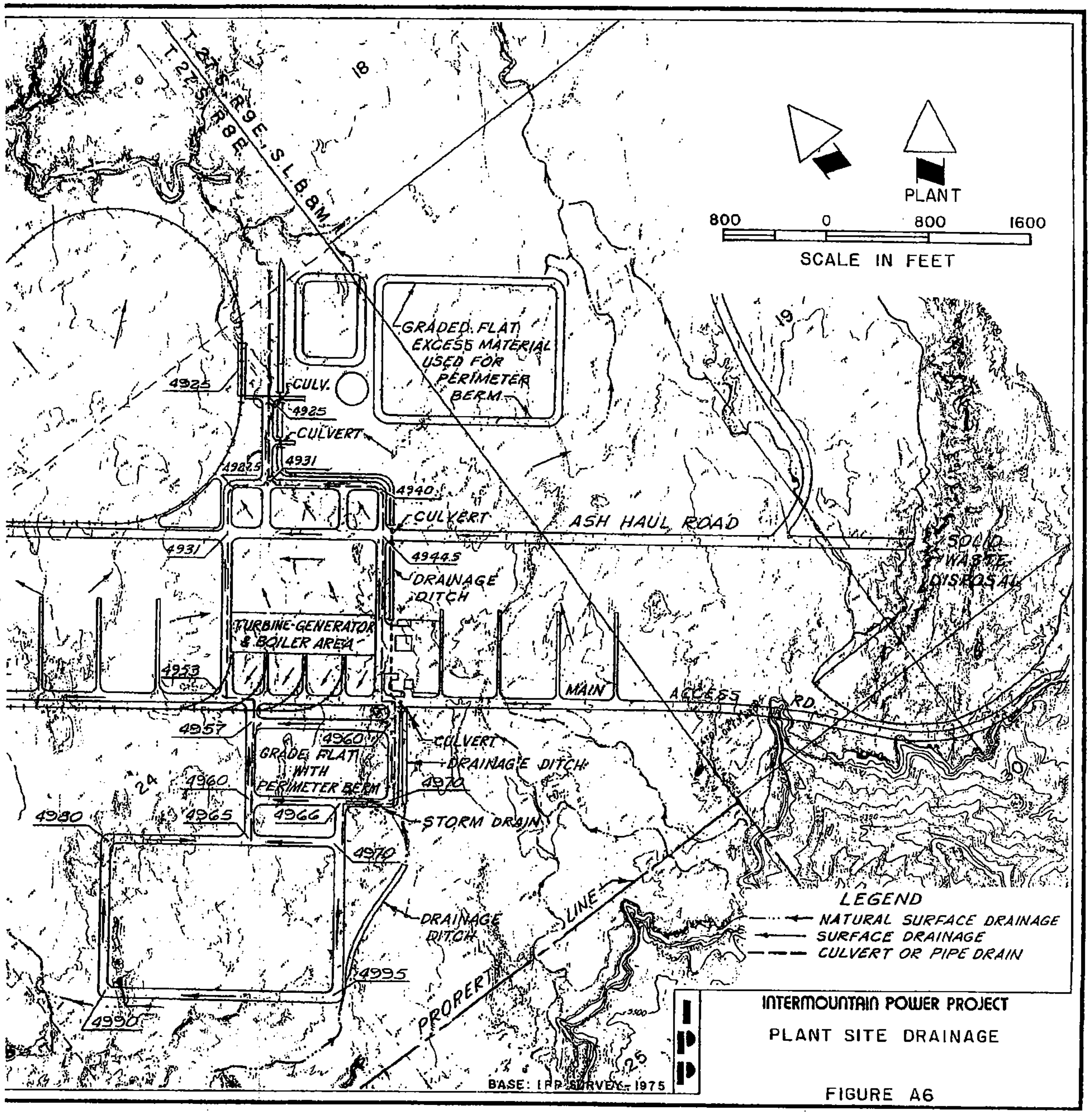


INTERMOUNTAIN POWER PROJECT

GENERAL SITE PLAN

FIGURE A5

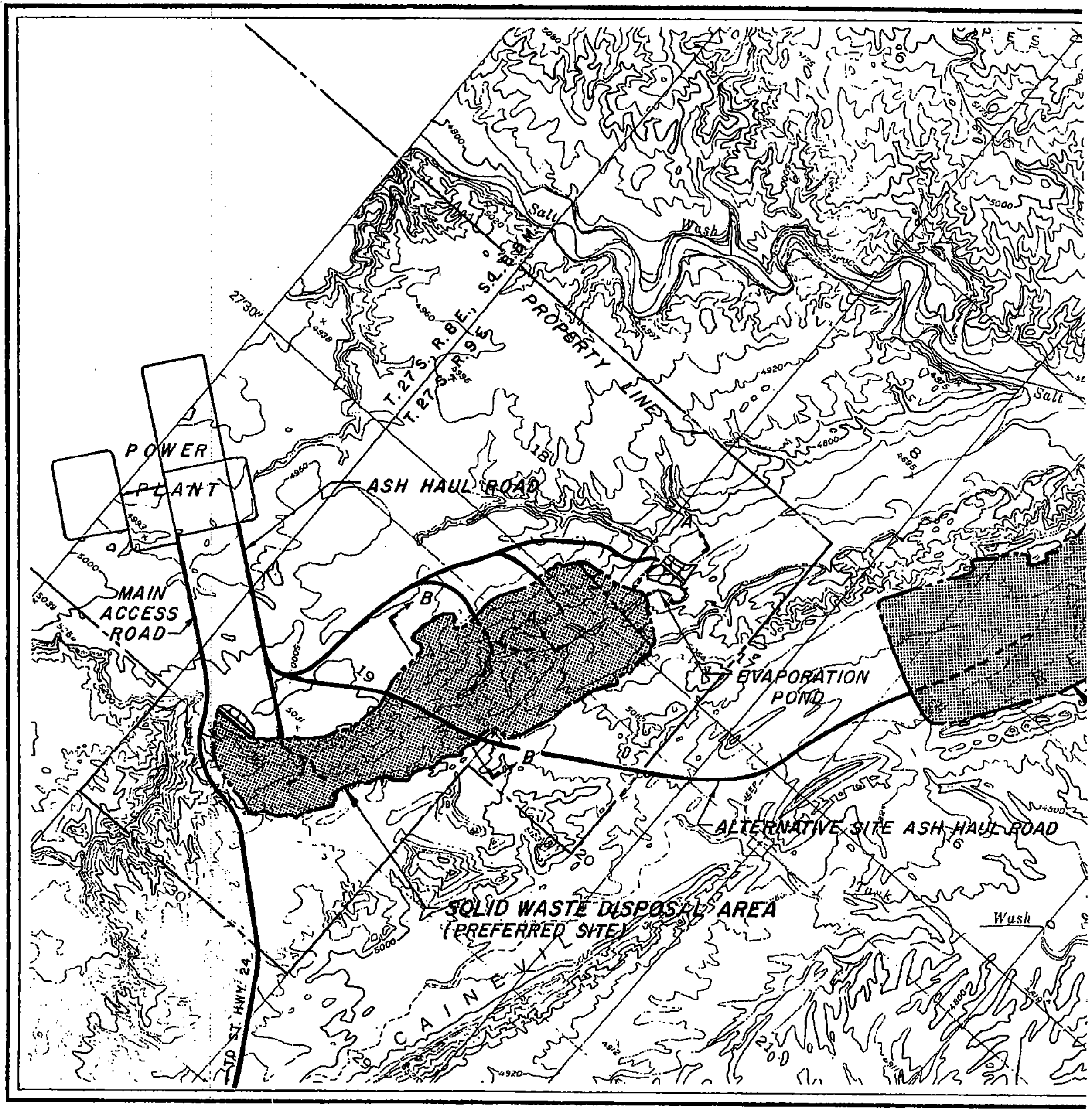

CULVERT
CULVERT
CULVERT
CULVERT
RAILROAD TRACKS
4920
4932
EVAPORATION PONDS
EVAPORATION PONDS
PROPERTY LINE
PROPERTY LINE
ACCESS ROAD
STORM RETENTION POND
13
14
15

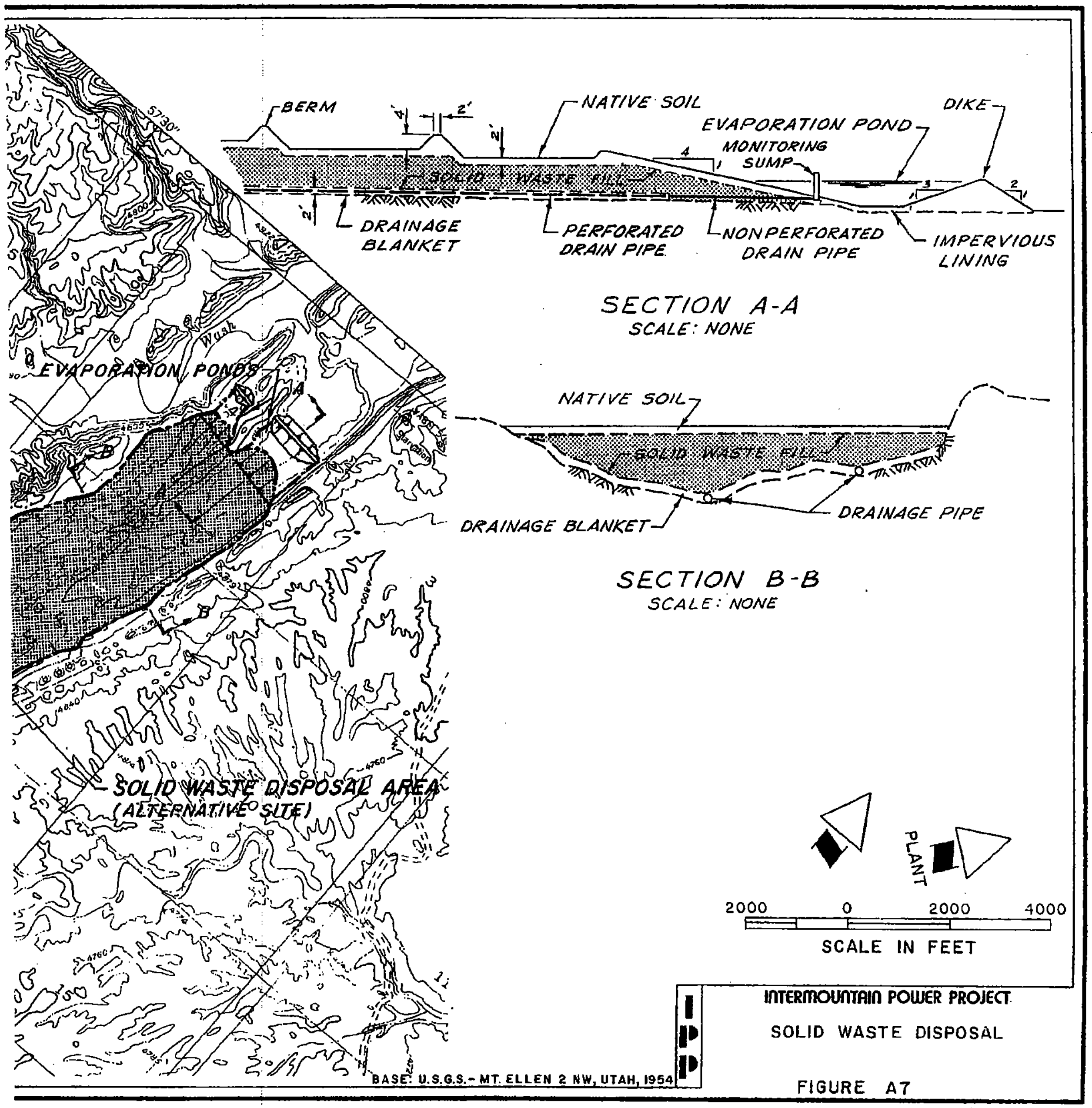


INTERMOUNTAIN POWER PROJECT

PLANT SITE DRAINAGE

FIGURE A6

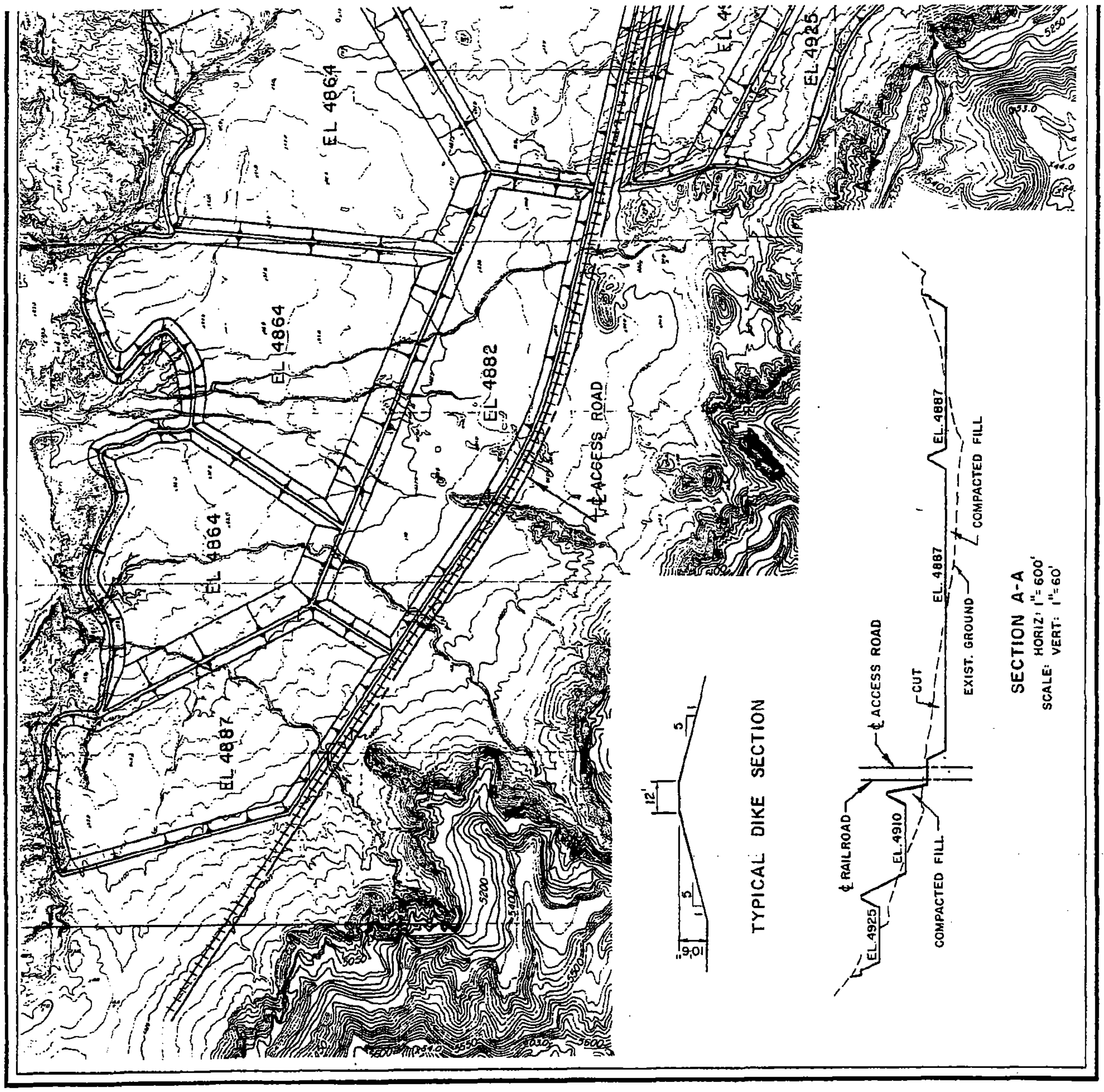

POWER PLANT
MAIN ACCESS ROAD
ASH HAUL ROAD
PROPERTY LINE
T. 27 S., R. 8 E.
T. 27 S., R. 9 E.
EVAPORATION POND
ALTERNATIVE SITE ASH HAUL ROAD
SOLID WASTE DISPOSAL AREA
(PREFERRED SITE)
CAINE
Salt
Wash
ST. HWY. 24
27'30"
B
19
20
18
8
16
21

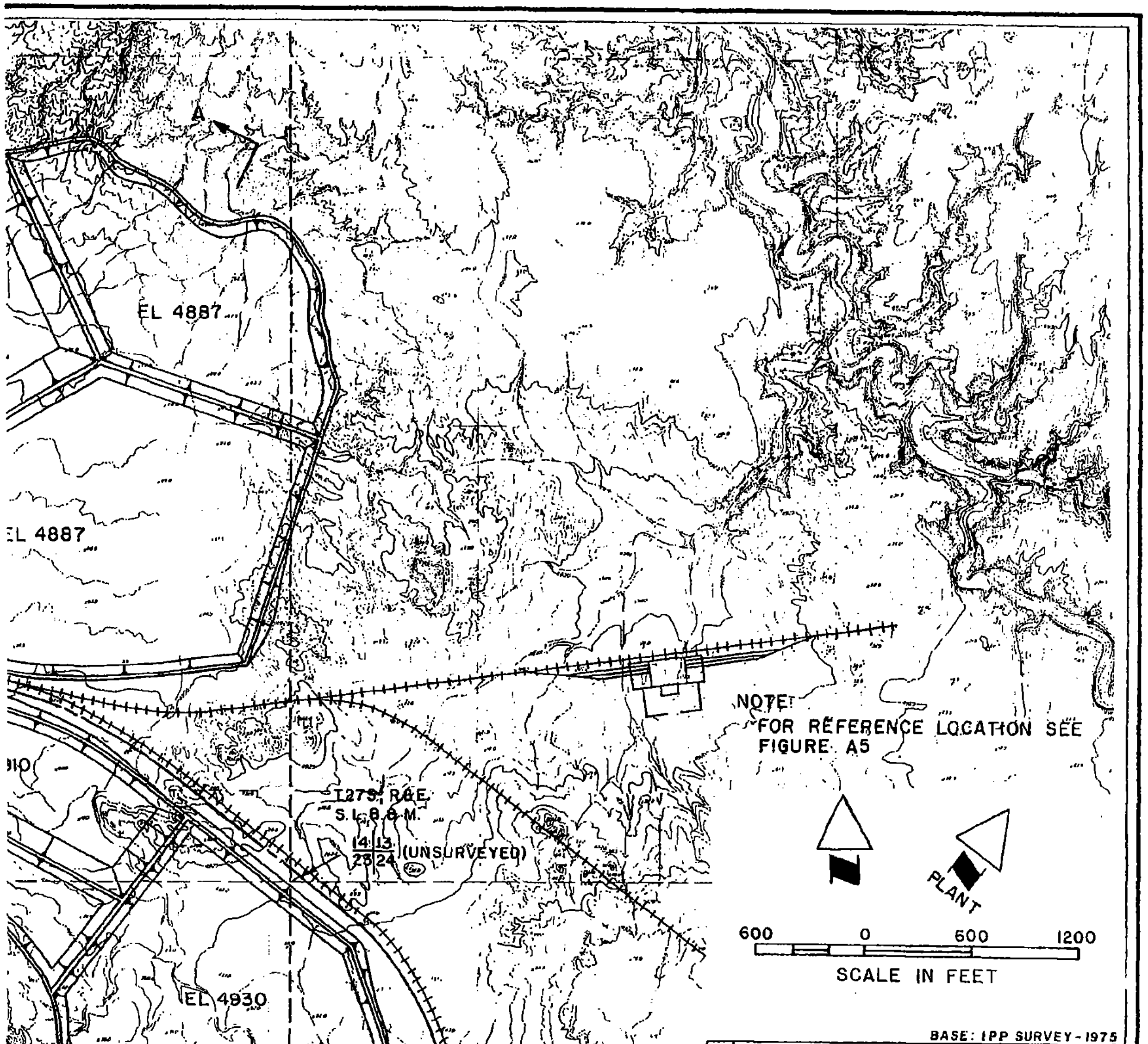


INTERMOUNTAIN POWER PROJECT

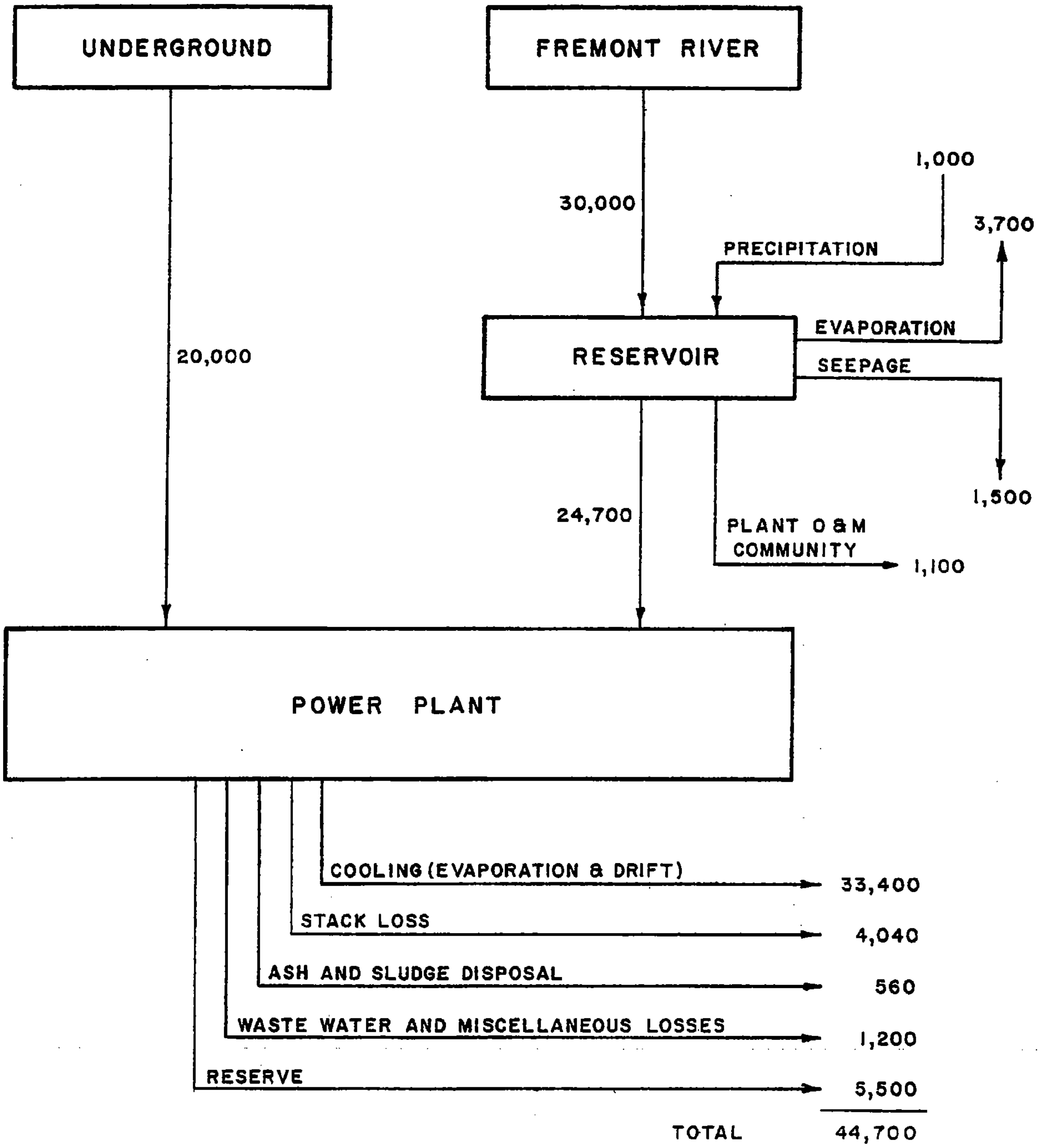
SOLID WASTE DISPOSAL

FIGURE A7


EL 4864
EL 4864
EL 4864
EL 4887
EL 4882
EL 4925
℄ ACCESS ROAD
TYPICAL DIKE SECTION
12'
5
1
10.6'
SECTION A-A
SCALE: HORIZ: 1" = 600'
VERT: 1" = 60'
℄ RAILROAD
℄ ACCESS ROAD
EL 4925
EL 4910
EL 4887
EL 4887
CUT
EXIST. GROUND
COMPACTED FILL
COMPACTED FILL



INTERMOUNTAIN POWER PROJECT
EVAPORATION PONDS
FIGURE A8

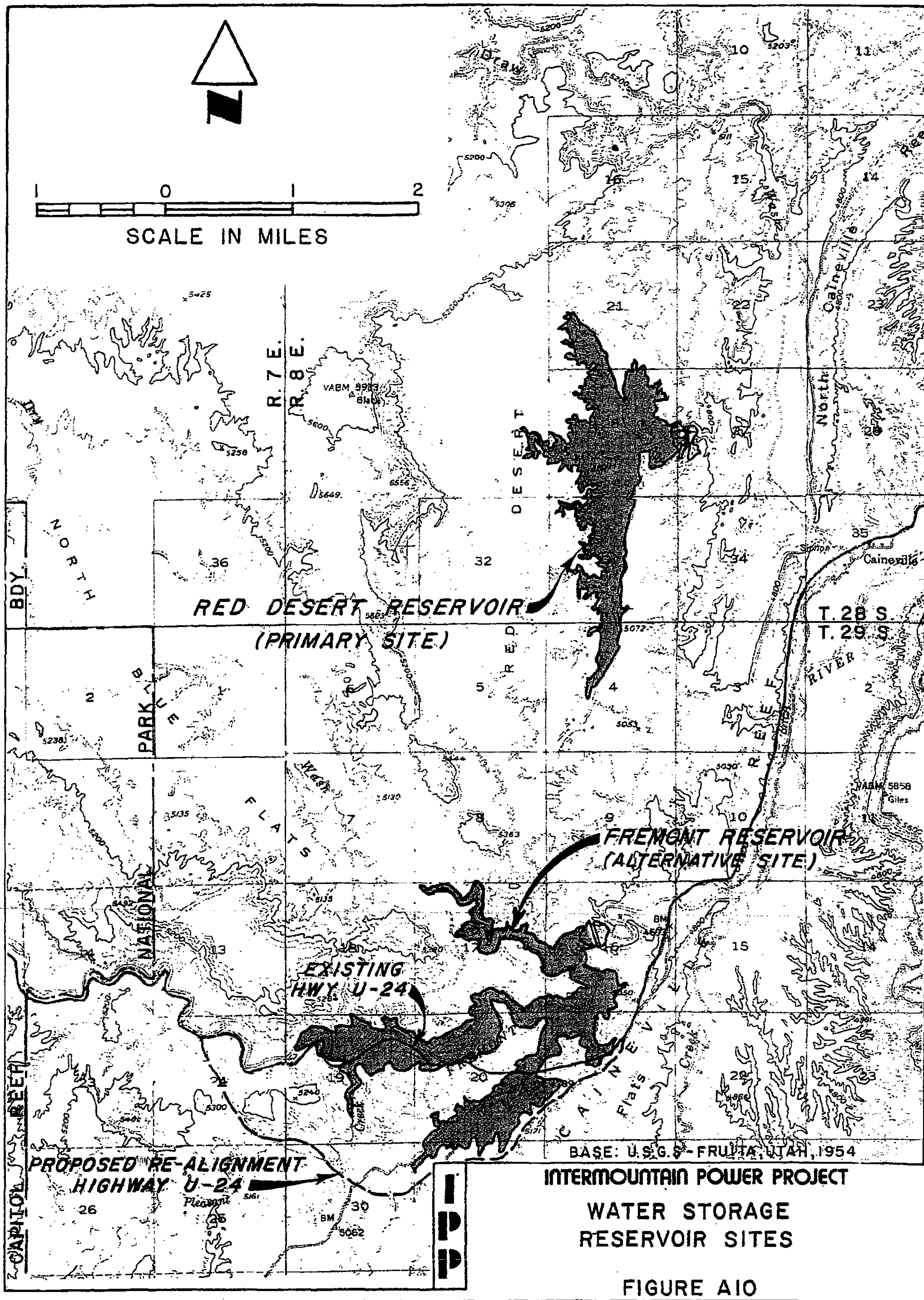


NOTE: ALL NUMBERS INDICATE ACRE-FEET OF WATER PER YEAR; BASED ON ANTICIPATED MEAN AVERAGES, NORMAL WEATHER CONDITIONS, AND AN 85 PERCENT PLANT CAPACITY FACTOR.

INTERMOUNTAIN POWER PROJECT

PROJECT WATER BUDGET

FIGURE A9



INTERMOUNTAIN POWER PROJECT

WATER STORAGE
RESERVOIR SITES

FIGURE A10